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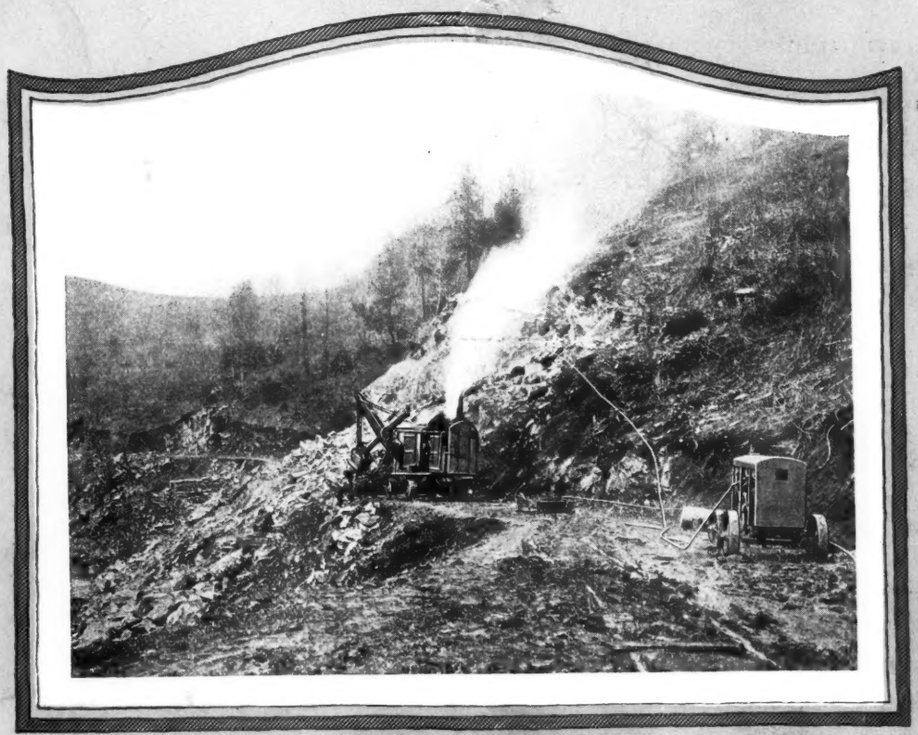

ROAD CONSTRUCTION IN NORTH CAROLINA. THE GASOLINE ENGINE DRIVEN PORTABLE AIR COMPRESSOR IS OPERATING "JACKHAMER" DRILLS.

Compressing Carbonic Acid Gas to Stimulate Plant Growth
Ben K. Raleigh

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Large —Clearance Easy —Operation

The Terry principle of operation possesses many features of superiority apart from high efficiency at slow speeds. These features are of particular importance to the operating engineer in charge.

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APRIL, 1922

Compressing Carbonic Acid Gas to Stimulate Plant Growth

Carbonic Acid Gas Scrubbed Out of Waste Furnace Gases and Pumped to Experimental Farm Fields Doubles and Triples Crop Yields

By BEN K. RALEIGH

FRANCE, confronted with the ruins of war, the impossibility of using many of the great areas where once she grew much of her plant food, and the need for making two blades of grass grow where one grew before, turned with confidence to her sons for a solution of her problems.

To her agriculturists she said, in effect:

"The North, the devastated territories of *"la Patrie,"* will not produce the plant food in the quantities customary to the years prior to 1914. This is a condition which we cannot overcome immediately. France has always been self-sustaining. She has raised sufficient food for all her population within her own borders. She did this in years of plenty and prosperity. She is now heavily in debt. Her economic position is perilous. It is, therefore, all the more necessary that she should now, of all times, continue to feed her people with her own home grown food. Not to do so means buying the food in the world market and such purchases we can ill-afford. Importation of food would mean an excess of imports over exports at a time when we are increasing our exports and decreasing our imports. It would undo the patient work of the years since the war. It would thus, automatically, depreciate further the franc and make the tax burden fall more heavily on the back and shoulders of every man, woman and child.

"The problem, therefore, is to make those portions of France untouched by war produce as much now as the whole of France produced before its vast agricultural regions of the north were laid waste. To this need *"la Patrie"* directs the attention of its devoted sons, serenely confident that they will address themselves to the task and accomplish the desired results.

CHARGING the atmosphere with an excess amount of carbonic acid gas has been known to increase the yields of greenhouse cultivation.

Monsieur Roque has, as described in this article, tried the experiment of growing crops in open fields over which the air content of carbonic acid gas had been raised above the normal proportion, and the results have been astonishing.

Since M. Roque's experiments similar trials have been made in the Ruhr coal fields, the method being much the same; waste furnace gases were scrubbed, compressed and sent through pipes to the fields.

What might the wholesale application of this method mean to crop yields if its use became practically possible?

"If the results are not accomplished France will be placed in a position similar to England, not able to support her own population and dependent upon the fertile acres of the American mid-west for the daily bread she puts into her mouth.

"Agriculturists! Your country calls upon you to redouble your efforts and by superhuman efforts to achieve the impossible."

An appeal like that is never lost upon a Frenchman, and especially upon those honest, hard toiling peasants who love their land so devotedly and who see in their few acres a patch of that great warm quilt they know and love as their own, their native land.

The agriculturists put their all into their jobs. They laughed at the eight-hour day, they jeered at law-made summer-time. They were up before the sun and they were at their tasks in the fields as long as sufficient light lasted. Not only men, but the women, the children; not only the horses, but the dogs. It was a consecrated, a holy task.

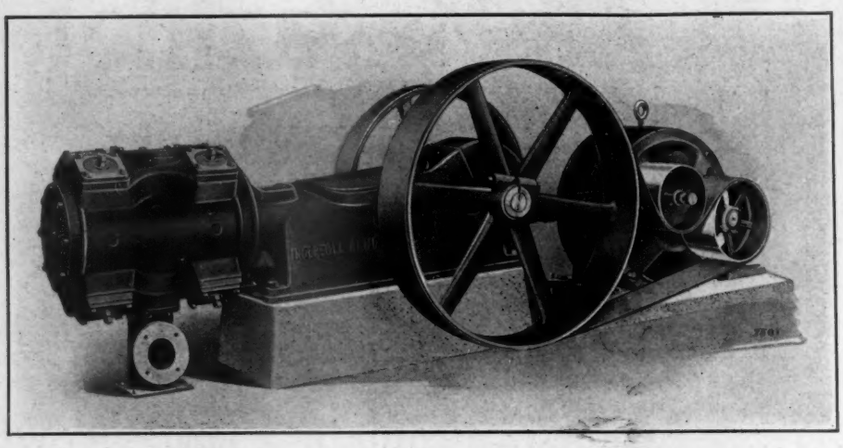
But two blades did not grow in the place of one. Crops were augmented, but not in sufficient quantity to offset the loss of the produce from the war ravaged territories. What was to be done?

Now in the Department of the Seine and Marne, outside the interesting old town of Melun and on the way to Barbizon, haunt of artists, birthplace of Millet, is the splendid farm of Monsieur Jean Roque. From his terrace he commands a sweep of fields and rolling foot-hills with the beautiful green bulk of the Forest of Fontainbleu as nature's superb drop-curtain.

Monsieur Roque is a gentleman-farmer. He has, in his own words, sufficient of this world's goods to enable him to make a hobby of farming. He is an ardent admirer of the great Henri Fabre, the author of the wondrous studies of insect life, although Fabre's home is faraway in the south of their beloved France. Fabre has devoted his life to the study of the teeming small life that makes a populous world of a tiny garden in the Midi. His result has been the astounding volumes which, eschewing the usual technical and scientific terms employed by the dry-as-dust entomologists who preceded him, have charmed and delighted thousands the globe over.

Fabre worked for love. He surrendered all thoughts of wealth, of even a modest competence and gave his life to the insect world without a hesitation. He often found his studies cruelly handicapped for the want of a special apparatus, the cost of which was too much for his attentuated purse. Roque conceived an ardent admiration for the man who gave all, gave his scores of years of life without an expectation, a hope of return.

"What Fabre did with nothing I can at least



Type of small electric driven compressor used to pump carbonic acid gas through the concrete pipes to the fields under cultivation.

try to do with my modest fortune," Monsieur Roque said to his wife in the early autumn of 1920. "The crops have not doubled, France is impeded in her strides toward recovery. Fabre has his insects. He saw them multiply; he watched thousands of little ones come forth from the eggs laid by a single spider, the monstrous *Narbonne Lycosa,* which after the nuptial night devours her husband. Why can't I, who have been a dabbler and an experimenter in chemistry, make plant life more fertile?"

Madame Roque, whose splendid skill as a cook I sampled in their great farmhouse a year after this question, told me she had smiled at her husband and replied that he had always made her very happy, that any experiments he conducted would at least be interesting to him, that if he by chance, found positive results, 31 millions of people, more or less, would be greatly benefited, he would be a great man and she would be yet more happy and love him more than ever, if that were possible.

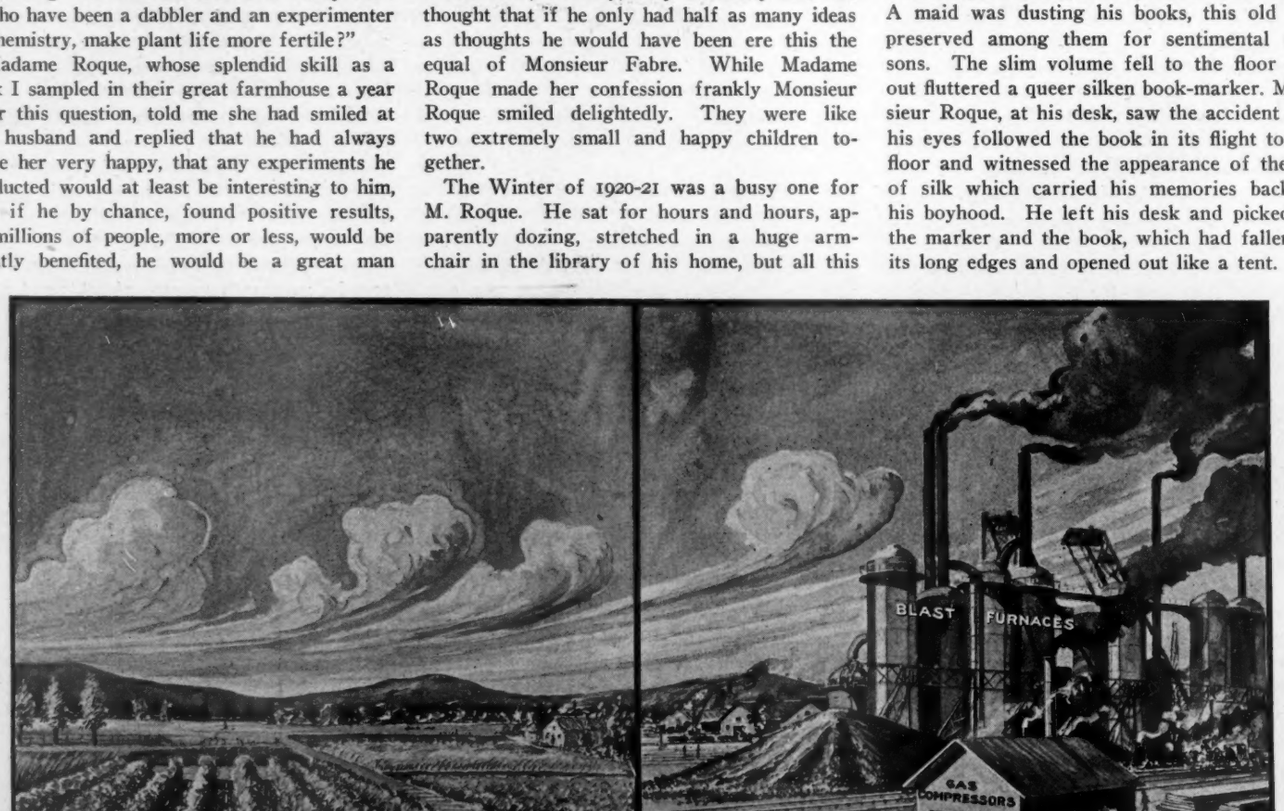
But, Madame Roque confessed to me, while M. Roque poured a sparkling Asti Spumenti from Italy, she hadn't thought anything was going to come of it, there wasn't even a suggestion as to how the great result was to be accomplished. She had smiled behind her husband's back, oh very, very discreetly and had thought that if he only had half as many ideas as thoughts he would have been ere this the equal of Monsieur Fabre. While Madame Roque made her confession frankly Monsieur Roque smiled delightedly. They were like two extremely small and happy children together.

The Winter of 1920-21 was a busy one for M. Roque. He sat for hours and hours, apparently dozing, stretched in a huge armchair in the library of his home, but all this time his mind was circling round and round his problem; his brain, like one of Fabre's insects, was buzzing about or spinning a web wherein to trap the great thought, to sink a barb of intelligence into its armor and sting it into submission.

Monsieur Roque asked himself whether the crops of France could be doubled by hard labor. His answer was an emphatic no, for he had seen how the peasants had worked from dawn to dusk with, it is true, an appreciable increase, but not the desired doubling. By fertilizers then, perhaps? But they had also been used and the crops had been stimulated as much as lay within the power and scope of fertilizers.

The solution is in science, Monsieur Roque at last concluded, and in the most modern kind of science. But first the fundamentals, and then the superstructure; first the bottom rung of the ladder must be trod before a climb to the top.

So back to elementals went Monsieur Roque. And in a book of his school-days he found a suggestion which set him feverishly to work. It was quite a simple statement and it was contained in a physiology. It was in a chapter devoted to the functions of the lungs. Monsieur Roque came upon it by the merest chance. A maid was dusting his books, this old one preserved among them for sentimental reasons. The slim volume fell to the floor and out fluttered a queer silken book-marker. Monsieur Roque, at his desk, saw the accident and his eyes followed the book in its flight to the floor and witnessed the appearance of the bit of silk which carried his memories back to his boyhood. He left his desk and picked up the marker and the book, which had fallen on its long edges and opened out like a tent. He



On the right a group of iron blast furnaces supplying an abundance of carbonic acid gas. This gas is scrubbed and then compressed by a compressor for distribution to cultivated areas on the left. A system of interconnecting concrete mains serve to deliver the carbonic acid gas wherever desired. The gas escapes freely from the perforated piping and commingles with the growing crops.

examined the marker then glanced at the page of the book as fate had thrown it open.

This is the elementary lesson he read:

"Human lungs breathe in the oxygen from the air and breathe out carbonic acid. Conversely, plants take in carbonic acid and breathe out oxygen. Oxygen is necessary for human life. Carbonic acid as contained in the air all about us is the most important factor in the growth of green plants."

Monsieur Roque sat down, quite stunned. Then his mind began to leap and play with the idea. What did physicians do when they wanted to stimulate heart action? They sent for a tank of oxygen and administered it directly to the patient. If carbonic acid was necessary for the growth of plants, why not administer concentrated acid directly to the plants just as physicians administered oxygen to patients, instead of leaving the plants to draw a meager supply out of the air where it was mingled with oxygen?

Monsieur Roque left his farm early the next morning and drove in to Melun where he took a train for Paris. Here he consulted officials at the Ministry of Agriculture, delved into books in the scientific libraries, called upon chemists, interviewed scientists. Out of this visit grew encouraging words from the Ministry of Agriculture and these basic truths which he co-related:

Carbonic acid is a prime requisite for plant life's healthy growth.

The proportion of carbonic acid in ordinary air is as three to ten thousand.

Plants which have been kept in a closed room and the proportion of carbonic acid then increased have thrived marvelously.

The great crops necessary to feed a nation cannot be grown in a closed room.

All this is very well, Monsieur Roque concluded. But no one has yet tried growing crops in an atmosphere charged with carbonic acid and outside closed rooms. Is it possible? Nothing that man has put his mind to is impossible! My problem, therefore, is to increase the content of carbonic acid in the air of our French fields much more than the normal proportion of three to ten thousand.

There followed correspondence with the four corners of the earth. From the United States M. Roque received facts concerning the use of carbonic acid for greenhouse cultivation. This information was to the effect that the greenhouse cultivation of tomatoes had proved absolutely successful. In a greenhouse the method is easy of manipulation. The American figures indicate that the yield of tomatoes can be increased 175 per cent. by the combined carbonic acid-hothouse method.

The Roque aim was 100 per cent., not 175. But it was an open field and not a greenhouse method.

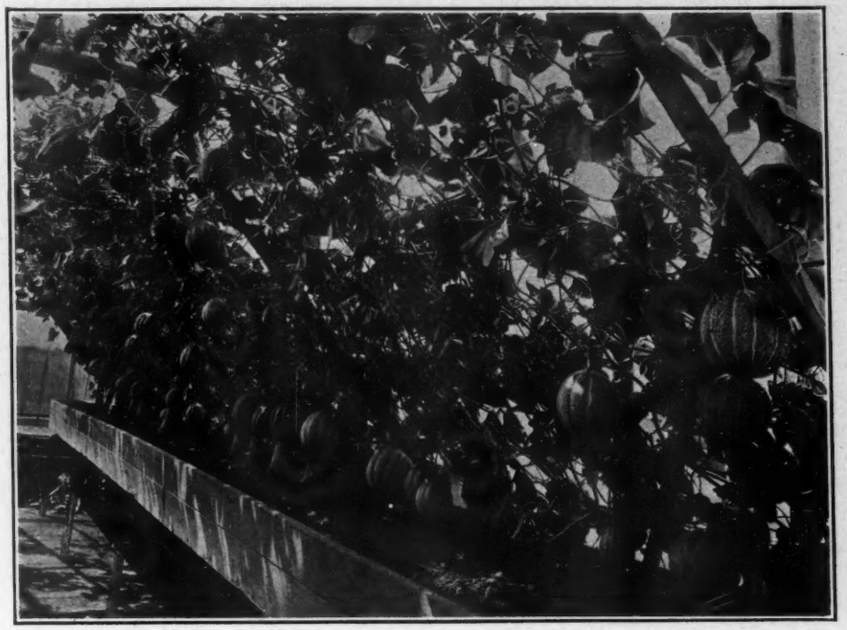
M. Roque sought out a Parisian scientist to whom he addressed this question:

"Where can I be assured of a constant source of carbonic acid?"

"At any blast furnace," he was told.

"But I want a constant source of carbonic acid at a spot where land is cheap and where I can establish an experimental farm."

Other advisers were called in, inquiries were made, long train trips were undertaken and finally, near the town of Boulay, between Metz and Sarrebruck, in Lorraine, there was found a blast furnace and about it idle open fields which M. Roque was able to lease on moderate terms.

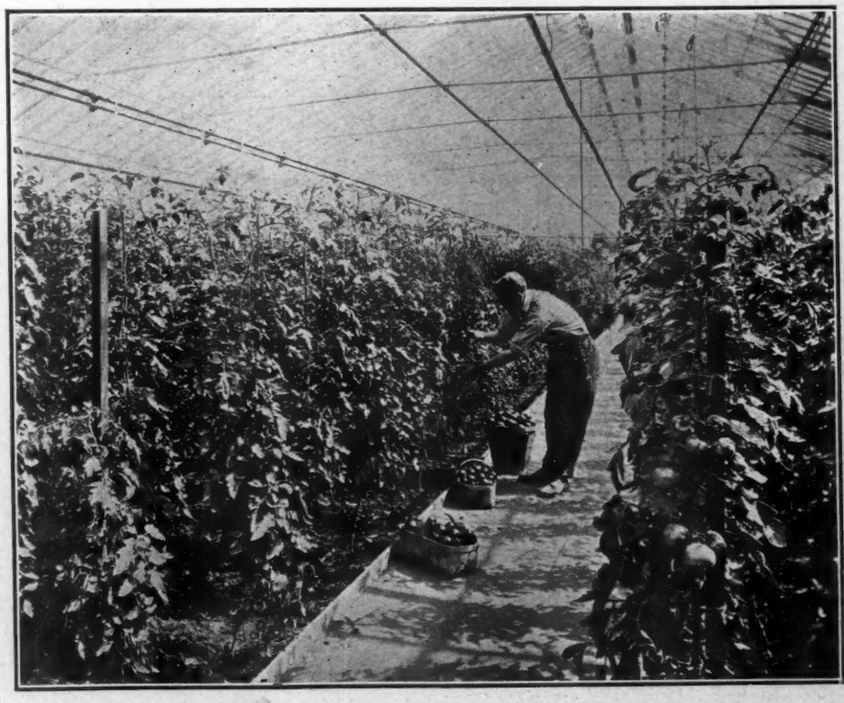


Especially large and luscious melons can be grown where the plants have a chance to inhale an atmosphere rich in carbonic acid gas.

With the co-operation of the blast furnace people M. Roque made his arrangements. His studies of his problem had made it quite clear to him just what he wanted and needed. There came to him in his new quarters, so far away from his own home, many boxes and crates. These gave up the mainspring of the whole Roque plan, the unassembled parts of a small Ingersoll-Rand air compressor.

The fields were planted with potatoes, sugar beet, barley, onions and peas. While they were taking root and growing M. Roque installed his air compressor. From it he ran concrete piping in all directions about his trial fields, with vents to permit the escape of carbonic acid at any or all points desired. The piping was merely laid along the ground, the idea being to make the experiments as inexpensive as possible.

The plants in time thrust their heads above



Note the luxuriant growth of these hot-house tomato plants. By giving the plants a chance to breathe an increased measure of carbonic acid gas a crop can be gathered far in excess of that produced under the usual conditions.

M. Roque boosted his yield of onions 300 per cent. above the normal by giving his plants more carbonic acid gas than could be obtained from the general atmosphere.

ground. The experiment began. The waste gases from the blast furnace had been analysed and found to be rich in sulphurous fumes and other poisons which would either kill or have a detrimental effect on the plants. So the waste gases were "scrubbed" and made free of these ingredients.

The compressor was started. The pure carbonic acid was compressed and sent into the concrete piping running all over the experimental fields.

A half mile away M. Roque had leased another field to which no pipes ran but which had been planted with the seeds of the same vegetables on the same day. This was the "check" field, designed to show whether carbonic acid released into the atmosphere from the surface of ground from which plants are growing, stimulated growth, improved quality or increased quantity.

Daily the compressor sent the carbonic acid through the concrete pipes and at the trial fields it was discharged into the air in the immediate neighborhood of the growing plants.

Months passed and then came the time of harvest, but long before that M. Roque had learned that his carbonic acid-compressor method had vindicated his ideas, his theories and his dreams. He had sought a 100 per cent. increase.

Here are the figures comparing the yield of the two fields both the same size, both planted with an equal quantity of seeds from the same bags on the same day:

Compressor carbonic acid potatoes yielded a crop more than four and one-quarter times as great as the untreated potato plants.

Compressor carbonic acid barley yielded a crop just slightly in excess of 100 per cent. of the untreated barley field.

Compressor carbonic acid onions yielded a crop 300 per cent. greater than that produced in the untreated field.

Compressor carbonic acid sugar beet yielded a crop 260 per cent. greater than that produced in the untreated field.

Compressor carbonic acid peas yielded a crop 340 per cent. greater than that produced in the untreated field.

The experiment was made during the spring and summer of 1921. It was during the months of June and July and the first part of August that France, along with the rest of the world, experienced the terrible drought which withered vegetation in its fields. The Roque experiments demonstrated that plants treated by the compressor carbonic acid method consumed much less water and that they did not suffer greatly in time of severe drought.

It is the opinion of M. Roque and of the agricultural experts who have examined his field that the yield would have been much greater had not great quantities of carbonic acid been blown away almost as soon as it left the pipes. But M. Roque observes that he aimed only at a 100 per cent. increase and that he has achieved that figure. He quite frankly says that the expense of piping, a first cost, is nevertheless likely to lessen materially the introduction of the method for open air crops among the cautious farmers of France who are disposed to resist innovations and especially innovations which mean financial outlay. Increased crops constantly year after year would soon repay many times over this initial cost, he maintains, but himself raises the objection that blast furnaces producing a constant and cheap supply of carbonic gas are not scattered over the French country-side. The next step, in his opinion, is the creation of an exceedingly cheap perforated piping, perhaps on rollers and movable at will, which can be connected with a compressor and moved about. It is his idea that such piping should be laid in the hollows of furrows with the perforations next to the earth so that the discharge of the carbonic acid would be downward and so that the gas would rise from the ground along the sides of the furrows, which would absorb some of it, and then up the plant stalks, where more would be directly breathed in by the plants.

A method for manufacturing on any farm, a constant and cheap supply of carbonic acid is also the next step to be solved. But M. Roque maintains, and the French Government's agricultural experts support his claim, that the way has been blazed, the successful method made known and that now it is a matter for engineering skill and brains to evolve a method that will make carbonic acid farming within the reach of even the poorest farmer.

Since M. Roque's experiments similar ex-

The farmer in this case is doing more than plowing the soil preparatory to planting. He is turning under grass which, when it decays, will generate carbonic acid gas and so promote the growth of the seed which he will sow.

periments have been made in the Ruhr coal fields, the method being the same, the waste gases being scrubbed, then compressed and sent through pipes to the fields.

An interesting point which has been established in connection with the Roque experiments is that the air above manured soils is richer in carbonic acid than is ordinary air. M. Roque contends that this can only point to one, the obvious, conclusion.

"The harmony of Nature," M. Roque observed "consists of a series of cycles. We have now established another cycle and it must be harmonious for it is natural. The growing things, the great trees of the forest, created coal. Now the waste gases from coal have completed the cycle and are making vegetation grow more plentifully, more luxuriantly. Great trees, coal, coal waste gases, increased vegetable growth."

The latest analyses of the Roque-method vegetables reveal the intensely interesting information that the starch and sugar content of vegetables grown by the compressor-carbonic acid system are appreciably increased.

And, still more remarkable, the condition which M. Roque set out to correct, has corrected itself by natural means. The figures for this year's harvest in the devastated regions of Northern France are expected to equal, if not surpass pre-war harvests in the same districts. This is only the third harvest since the war but already the region has attained the leading place in the agricultural yield of all France.

The progress of wheat production in the Department of the North has been constant since 1909 and, but for the interruption of the war, when fields were torn up and research laboratories were destroyed, it might have reached a point to be envied by the other wheat-producing centres of Europe.

In 1909 the average wheat production of France was only thirteen quintals per hectare, as against 21 in Germany, 24 in Belgium and Holland and 27 in Denmark. By 1913 the French figure had risen to 24, the contribution to the increase coming largely from the North. The farmers of Northern France, under the guidance of agricultural experts, are slowly evolving, by means of seed selection, a wheat stock admirably suited to the climatic conditions of their region.

What will they produce if wholesale use of the compressor-carbonic acid method becomes possible?

Investigations have shown, according to the *Iron and Coal Trades' Review*, that the moisture in air at an altitude of 100 ft. above ground level is about 20 per cent. lower than at ground level, both measurements being made in the neighborhood of a blast-furnace. To meet these conditions, the blowing engine house at the Rombas works was arranged with the suction orifices of all the eight gas-driven blowing engines in a common suction tower 138 ft. high. After the new blower was completed, in 1915, measurements were carried out, with the result that it was found that air taken through the top of the tower contained, on an average, 12 per cent. less moisture than air at ground level.

HETCH HETCHY WATER SUPPLY PROJECT

SOME VERY excellent drilling progress records have been made recently on the Hetch Hetchy water supply tunnels.

The record made at the Priest heading is truly a remarkable achievement. To advance an eleven foot three inch section tunnel, 25 feet per day indicates a highly perfected organization using correct drilling equipment.

The following table shows the progress made during and at the end of August, 1921:

Tinkler, is in close touch with every step of the work and has been personally supervising that part done at South Fork, both East and West, adits five and six, both East and West as well as at Chutake. The work done at the East and West headings at Big Creek and Priest is being handled under sub-contract by Mr. A. C. Dennis, of Dennis & Wilson.

Mr. M. M. O'Shaughnessy, City Engineer is directing the project. He is assisted by Mr. N. A. Eckart, Assistant City Engineer, and Mr. L. T. McAfee, Resident Superintendent.

CITY AND COUNTY OF SAN FRANCISCO, MOUNTAIN DIVISION TUNNELS, HETCH HETCHY WATER SUPPLY

Heading	Tunnel Section	Character of Rock	Holes per Round	Superintendent	Shifts worked	Progress feet per month	Total Progress to date
Intake	13 ft. 8 in.	Monolithic Granite	45				
			48	Johnson	62	273	7,179
South Fork, East	13 ft. 8 in.	Granite	48	Peterson	67	424	7,020
South Fork, West	13 ft. 8 in.	Granite	45	Peterson	69	477	2,795
Adit 5-6, East...	13 ft. 8 in.	Granodiorite	38	Gallagher	62	300	1,017
Adit 5-6, West..	13 ft. 8 in.	Diorite	34	Gallagher	93	406	1,070
Big Creek, East.. from shaft	11 ft. 3 in.	Diorite	23	Fowler	62	414	3,125
Big Creek, West.	11 ft. 3 in.	Diorite	25	Fowler	62	420	4,117
Priest	11 ft. 3 in.	Altered Slate	25	Hickman	93	776	11,130
						3,490	37,453

Leyner-Ingersoll No. 248 Drifters were used exclusively on all the above headings.

A complete story of the entire project will soon appear in these columns. Just now it will suffice to say that it is one of the greatest municipal undertakings ever attempted. The flood waters of the Tuolumne River and its tributaries in the Sierra Nevada Mountains are to be collected, stored and transported through mountain tunnels and across the San Joaquin Valley and Santa Clara River into the City of San Francisco.

The contract for the nineteen miles of tunnels was awarded to the Construction Company of North America. This company's president and general manager, Mr. Charles C.

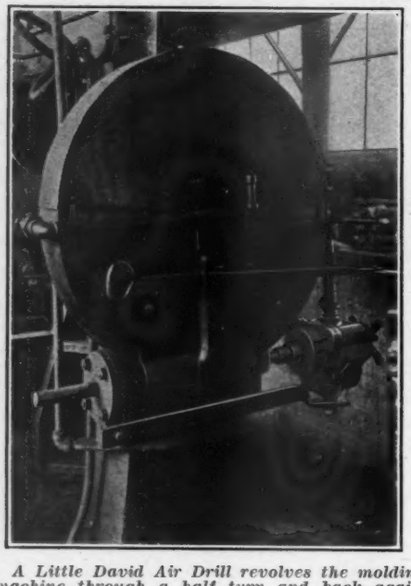
POWER ALCOHOL "IN SIGHT"

An interesting report growing out of the work done by the British government to find out the prospects of obtaining power alcohol within the Empire during the war has been issued by the Fuel Research Board covering the production of this commodity in Canada and shows that the 10,000 tons of wood waste and sawdust destroyed each day in British Columbia is capable of supplying from 40,000,000 to 50,000,000 gallons of power alcohol. Nothing is said of the costs involved for collecting this waste, the erection and operation of the plants, the chemicals, etc., required, or the ultimate cost of production.

Here are some of the men who drove the Priest tunnel in which a new record for tunnel driving was established. Hercules 40 and 60 per cent. gelatin was used. The man whose hand is resting on the headlight is Supt. Fred Hickman.

AIR DRILL SAVES LABOR ON MOLDING MACHINE

THE USE of a pneumatic drill to turn a molding machine, instead of the former method of revolving by hand, proved a labor saver for a Birmingham foundry. The company installed a No. 11-B Little David Drill to revolve the molding machine through a half turn and back to normal again. This work was then accomplished in about fifteen seconds for each operation which was a great deal faster than was possible by hand. The air drill saved the labor of one man on this job.



A Little David Air Drill revolves the molding machine through a half turn and back again, saving hand labor.

As is shown in the illustration the drill is held in a horizontal position with the crank case down. The spindle is directly connected to the worm shaft which drives a large worm gear, keyed directly on the central revolving axis of the molding machine. The shop mechanic rigged up a clamp on the throttle handle with a lever handle attached, which moves through a distance of about 8 in. This enables the drill to be operated without throwing the load on too suddenly. The machine is lubricated by removing a plug from the crank case and forcing in grease with a grease gun.

ALABAMA CO.'S MUSCLE SHOALS POWER PROJECT

Hydro-electric power could be developed sufficiently to industrialize an area of 800 miles in diameter with the centre at Muscle Shoals, Ala., was promised in a statement made by Thomas W. Martin, President of the Alabama Power Company, if Congress accepted the offer of that company for purchase and development of the Government-owned projects at the Shoals.

Thorough studies had been made of power markets within a radius of 400 miles of Muscle Shoals, Mr. Martin said, and applications for energy already filed with the power company convinced him there was need for developing Muscle Shoals and distributing the power throughout that section of the country.

NOVEL USE OF LIQUID AIR

INVESTIGATIONS for the purpose of devising a method for breaking the shells of chicha nuts and at the same time releasing the kernels without crushing them have recently been undertaken by the U. S. Bureau of Standards. Chicha nuts grow in South America; and during the World War the shells were extensively used in the manufacture of charcoal for gas masks. The kernels, however, are rich in oil, somewhat like that extracted from copra, and is of value as a foodstuff.

The shells of the chicha nuts are hard to crack, and it takes a pressure or blow of about 1,800 pounds to shatter them. For this reason, it is well-nigh commercially prohibitive to utilize the kernels as a source of edible oil. The problem confronting the Bureau of Standards has been to discover an agency that would increase the brittleness of the shells so that they would more readily respond to a much lighter blow and leave the kernels undamaged.

To this end, the nuts were placed in liquid air for a while; and when withdrawn the shells could be cracked with a heavy hand sledge. The only drawback to this procedure was that the kernels were also broken into many small pieces. The next step in the research consisted in cooling the nuts in liquid air for only half a minute. The action of the refrigerant made the shells sufficiently brittle so that they would crack easily; and inasmuch as the kernels were not frozen, and thus rendered friable, they could be released from the shells with but a trifling measure of injury.

The Bureau recognizes that considerable experimenting will still have to be done before this method can be developed to a point where it will be fit for practical application. However, the experts are satisfied that they have hit upon a solution of the problem that will probably warrant, in the near future, the establishment of liquid-air plants near groves where the chicha nuts are grown so that the kernels may be extracted whole. Vegetable oils are becoming yearly of greater importance for food and other purposes; and the chicha nut probably is not the only very hard-shelled nut which could be utilized profitably if cheaper means of getting out the kernels satisfactorily were available.

TUNNEL JOB BIDS OPENED

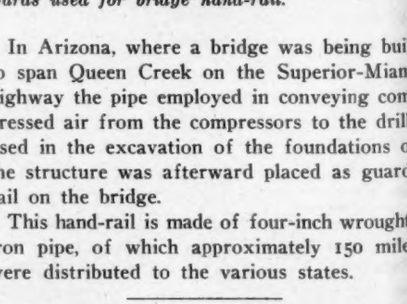
BOOTH & FLINN, Ltd., 17 Battery Place, New York, was low bidder on the contract for construction work on the Hudson River vehicular tunnel, bids on which were opened at the Hall of Records, New York, Feb. 15, its price on contracts Nos. 3 and 4 being $19,331,723.50. Among the itemized bids a price of $57.50 per ton was submitted on the 33,200 tons of cast iron segments in contract No. 3 and $47.50 per ton on the 72,300 tons of cast iron segments in contract No. 4, totaling $1,782,840 and $3,434,250, respectively.

Booth & Flinn, Ltd., has handled numerous tunnel and subway construction contracts, among the most recent being the tunnel extending from Clark Street, Brooklyn, to Old Slip, New York, built for the Interborough Rapid Transit Co. and the Montague Street tunnel in Brooklyn, constructed for the Brooklyn Rapid Transit Co.; a tunnel from Fourteenth Street, New York, to North Seventh Street, Brooklyn; tunnel construction in Newark, N. J., for the Passaic Valley Sewage Commission; Liberty tunnel through rock, for Pittsburgh, and several contracts on clay tunneling for sewers in Detroit.

Quotations on some of the iron and steel items in the Booth & Flinn bid were as follows: On the 2,000 ft. of wrought iron or steel pipe, one-inch to four inch, quotations ranged from 40c. to $1.70 per ft. and totaled $2,130; on 34,400 ft. of galvanized iron electric conduit the prices were from 15c. to 75c per ft. and totaled $10,468.50; on the cast-steel tunnel lining totaling 9,050 tons, $85 per ton was the price submitted in contract No. 4, and $90 per ton on contract No. 3, totaling $769,750; on cast-steel pile segments the total was 370 tons and the prices $85 and $90 per ton; on 15,550 ft. of cast-iron service pipe, ranging from six-inch to twelve-inch, $1.40 to $3.50 per ft. was quoted; on bolts and nuts the total was 4,615 tons at $150 per ton, totaling on both contracts $692,250.

COMPRESSED AIR PIPE SERVES AS HAND-RAIL

REFERENCE is made to the ingenuity displayed in salvaging pipe distributed by the Bureau of Public Roads, United States Department of Agriculture, to the State highway departments under Congressional legislation disposing of surplus war materials, equipment, and supplies.



Iron pipe for conveying compressed air afterwards used for bridge hand-rail.

In Arizona, where a bridge was being built to span Queen Creek on the Superior-Miami highway the pipe employed in conveying compressed air from the compressors to the drills used in the excavation of the foundations of the structure was afterward placed as guard-rail on the bridge.

This hand-rail is made of four-inch wrought-iron pipe, of which approximately 150 miles were distributed to the various states.

Brazil will have an international radio central at Rio de Janeiro, according to the announcement of recently completed plans, which will be modeled after the gigantic station at Port Jefferson, L. I. The new venture will be constructed by a European radio company which will also build a substation at Para, in the northern part of the same country.

Research Reveals How to Ventilate the Hudson Tunnel

Tests Disclose Much Valuable Data to the Pneumatic Engineer—Method of Providing Fresh Air and Disposal of Foul Air

By ROBERT G. SKERRETT

THE VENTILATION of the Hudson River vehicular tunnel involving the removal of the toxic carbon monoxide gas contained in quite injurious quantities in the exhaust from the gasoline engine was an important phase of this problem.

In this article the author describes how experiments were conducted to determine the amount of fresh air required, the means of propulsion and transmission, and other factors involved in order to insure against any physical discomfort occurring to anyone using the tunnel.

These experiments were conducted on an extensive scale in which the actual conditions to be encountered were reproduced and the results obtained have added much valuable material to our scientific knowledge of the subject.

THE OFFENSIVE character of the exhaust gases from numerous self-propelled vehicles is a matter of unpleasant familiarity to most city dwellers. This state of affairs is particularly marked where the highway is a crowded and, perhaps, a comparatively narrow one, and when hundreds of automobiles and motor trucks traverse the route continually at an average speed of ten miles or so an hour.

The public would have more reason for complaint if it were not that the open air and the breezes dilute and carry these fumes away with measurable promptness. Imagine what would happen, however, if the street or avenue were an enclosed viaduct—then the gases would be apt to accumulate and the atmosphere, thus vitiated, would, in all likelihood, become an actual menace to life.

The foregoing picture is painted merely that the public may grasp something of the problem which has confronted the engineers responsible for the planning of the Hudson River vehicular tunnel, which is to promote rapid intercourse between New York City and the neighboring municipalities of New Jersey. This undertaking will consist fundamentally of two cast-iron tubes, each of a maximum diameter of 29 feet, lying 60 feet below the surface of the water at mean low tide, and having a span from portal to portal of fully 8,500 feet.

When first ready for service, the daily traffic will involve the movement of approximately 17,000 conveyances, most of which will undoubtedly be of an automotive character. By the end of the sixth year the vehicular tide will be made up of the to-and-fro passage of substantially 24,000 vehicles in the course of 24 hours, and by that time the percentage of self-driven cars and trucks will have increased to a marked degree. By 1940, it is computed that the tubes will be used on an average daily by something like 56,000 conveyances, among which the horse-drawn vehicle will be less and less in evidence.

It is obvious, from the figures cited, that a steadily augmenting volume of noxious gases will have to be dealt with and disposed of lest the air in the tubes become foul and imperil the physical wellbeing, if not the life, of persons and animals traversing these subaqueous highways. Mr. Clifford M. Holland, Chief Engineer, and his technical associates of the joint New York and New Jersey Tunnel Commission have been keenly alive from the very start to this vital aspect of their problem; and the burden placed upon them has been all the heavier because very little helpful data could be obtained from the practical operations of other under-water vehicular tunnels.

As these experts pointed out a year ago, the usual method employed in ventilating railroad tunnels, for instance, is to blow fresh air through the viaduct from end to end—forcing the air in at one portal and allowing it to escape at the other. To ventilate the twin tubes of the Hudson River vehicular tunnel in this fashion would require a very large volume of circulating air and would entail excessive air velocities along the roadways, especially at points near the supply nozzles. Modifications of this system, in which shafts were to be utilized to shorten the distance between the intake and the exhaust portals, were considered, but this arrangement, in itself, was found unsuited and not likely to radically better conditions.

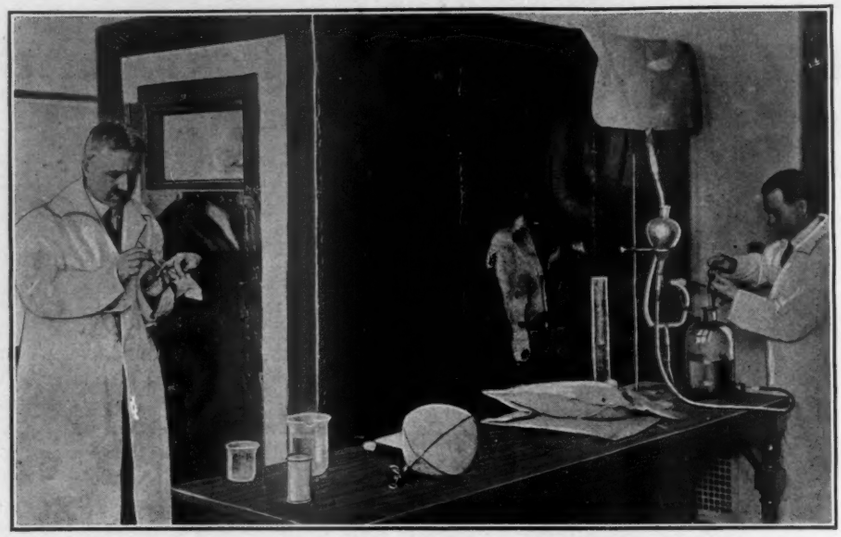
Finally, after considerable deliberation, the engineers of the commission settled broadly upon a scheme which would introduce fresh air into each tube through a number of openings leading from a supply duct—this passage to be separated from the roadway, and carry off the tainted air by another duct of a kindred character. This disposition of ducts promised to avoid excessive air velocities and likewise to insure throughout the length of each tube a uniform distribution of fresh air and a corresponding withdrawal of the atmosphere admixed with hurtful gases. Certain experiments made in 1916 seemed to indicate that it would probably be advisable to place the fresh-air duct below the roadway and the exhaust duct above the ceiling, and this arrangement was tentatively agreed upon until further tests could be made to settle this moot question.

There was no lack of professional men, some of them of excellent standing, who were ready to prophesy that the tubes would, in substance, be death traps even before the number of motor-driven vehicles reached the estimated maximum; and they pointed gloomily to the rapid rate at which self-propelled conveyances were supplanting horse-drawn wagons, trucks, etc., in the traffic ferried across the Hudson. A number of these men declared that it would be next to impossible to dilute or to neutralize the baneful gases discharged by internal combustion engines while running the length of the tunnel; and others freely proclaimed that the gases entering the living body would remain so long in the system that there would be a cumulative poisonous effect in the case of individuals making two or more trips during an interval of 24 hours.

Finally, there were some gratuitous advisers who did not hesitate to say that the method of ventilation planned by the tunnel engineers was radically wrong in principle. Here was a great public enterprise, bound to cost many millions of dollars, and it was of prime importance that no matters concerning its safe and efficient operation upon completion should be left to speculation. Therefore, the authorities wisely decided to clear up all of the ventilating problems by practical tests carried out in ways and upon such scales as would furnish conclusive data. This research work has been finished; and in its successful prosecution has called for a total outlay of 80-odd thousand dollars.

These extremely illuminating investigations have been fourfold in their nature, and have supplied information which will be of outstanding value in a number of fields of engineering. Indeed, some of the results directly contradict previously accepted theories, and by reason of this are epoch-making in their significance. The first two lines of inquiry had to do with the character and quantity of the exhaust gases generated by internal combustion engines when running and with the physiological effects of certain components of these gaseous mixtures—particularly carbon monoxide.

The purposes of the latter research were to ascertain how human beings and animals would react when breathing for different intervals an atmosphere polluted with various proportions of carbon monoxide. The desire was to determine how long such admixtures could be inhaled without injury to health, and to establish the maximum of carbon monoxide that might be carried into the body the while without harming even persons of feeble constitution.



An exterior view of the small experimental chamber at Yale. The physiologist at the left is withdrawing a sample of blood from the finger of a volunteer placed within the chamber. The subject's hand is projected through a slit in an elastic panel.

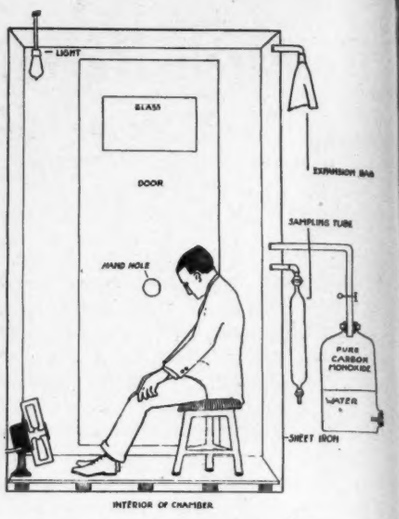


Diagram of small experimental chamber at Yale used for ascertaining the physiological effects of inhaling air carrying varying percentages of pure carbon monoxide.

Inasmuch as the questions for investigation were closely allied with the proper ventilation of many mining undertakings, the U. S. Bureau of Mines stood ready to collaborate with the Tunnel Commission, and the Government has, therefore, played a notably helpful part in the prosecution of the several phases of the whole inquiry. Road tests with 101 motor vehicles, including representative types of passenger cars and trucks, were conducted by the U. S. Bureau of Mines at the Pittsburgh Experiment Station, in accordance with a program laid out by Mr. Holland. These tests extended over an interval of ten months, beginning in December of one year and ending on the last of September succeeding—thus covering both winter and summer operating conditions.

The cars used were taken at random from those offered by private individuals, corporations, and automobile dealers of Pittsburgh; and under the circumstances the results may be considered fairly typical of motor vehicles actually running on the streets at divers speeds and upon changing grades. No alterations of carbureters or other adjustments were made; and the cars and trucks contended with physical situations much like those which will exist in the two tubes.

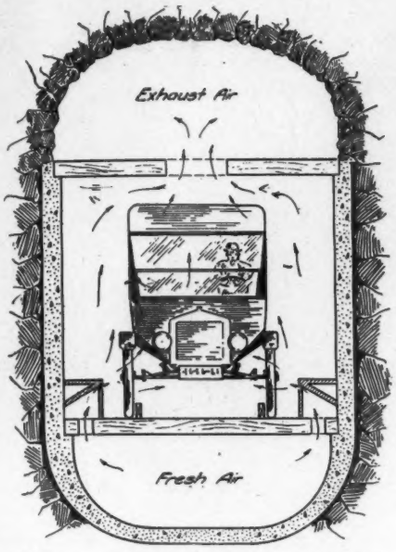
It does not serve the present purpose to describe at length the painstaking investigations made at Pittsburgh, nor the agencies employed to gather and to analyze the exhaust gases given off by the cars when accelerating, when climbing a grade or descending, when the vehicles were standing and their engines racing, or when similarly halted and the engines idling. It suffices for us to know that it was discovered that the average volume of carbon monoxide produced was considerably higher than previously computed. This meant that the ventilating plant would probably have to deliver more fresh air into each tube than had originally been deemed necessary. Here was a revelation that potentially entailed a larger blower equipment and a heavier annual outlay for electric power.

Happily, physiological inquiries at New Haven led to disclosures that offset the findings at Pittsburgh. This work was conducted at Yale University under the supervision of Professor Yandell Henderson, acting pro tem for the U. S. Bureau of Mines and indirectly for the Tunnel Commission. It was recognized by this physiologist that, inasmuch as the ventilation of the tunnel ought to be ample enough to obviate not only danger but even slight discomfort to persons in transit, his function was to ascertain the maximum permissible absorption of carbon monoxide by the body within the limit just mentioned. Prior to this investigation at Yale there was no precise definition of allowable vitiation of the air by admixture with carbon monoxide.

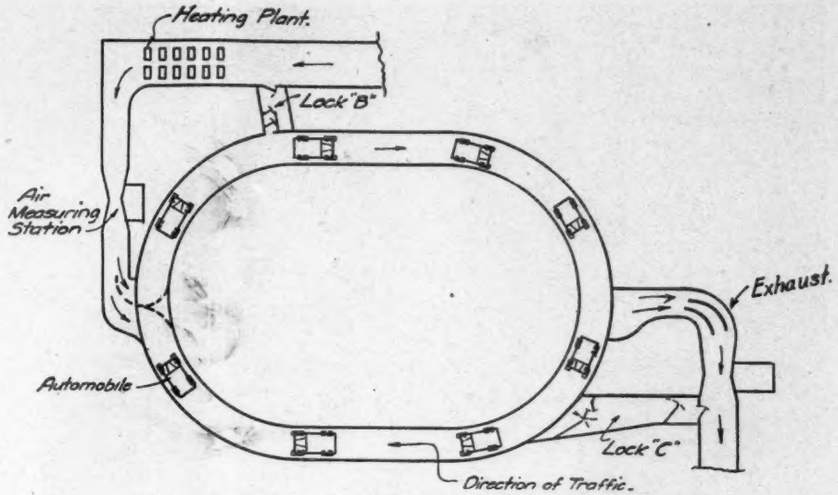
At first, it might appear that the ventilation of any closed space should be such as to insure air quite as pure as that of the city streets; and had this standard been adopted there would have been no need for research, for a basis of one part of carbon monoxide in 10,000 parts of air might have been accepted at once. This was impracticable, with tubes having a length of 3,800 feet between ventilating shafts, unless the "blow-through" system was employed, which would demand an air stream moving from end to end of the tunnel at a speed of 30 miles an hour! The tunnel engineers had earlier estimated that it would not be unsafe for passengers in the tubes to breathe an atmosphere containing three parts of carbon monoxide in 10,000 parts of air; and they had planned that the atmosphere in each tube should be changed completely at regular intervals of 90 seconds. Even so, it was recognized that the ventilating plant would have to be made up of 65 electrically-actuated blowers, ranging from twenty to 300 horse-power each; and this equipment was sure to call for heavy annual expenditures for operating current. Professor Henderson, after exhaustive experiments on human beings and animals, proved that a still higher percentage of carbon monoxide

Courtesy, Bureau of Mines.

Taking a blood sample from the finger of a driver of one of the test cars after a run for the purpose of determining percentage of saturation of the blood with carbon monoxide. A sensitive spectrophotometer was used in this work.



Section of experimental tunnel, Pittsburgh, Pa.



Plan of experimental tunnel, Pittsburgh, Pa.

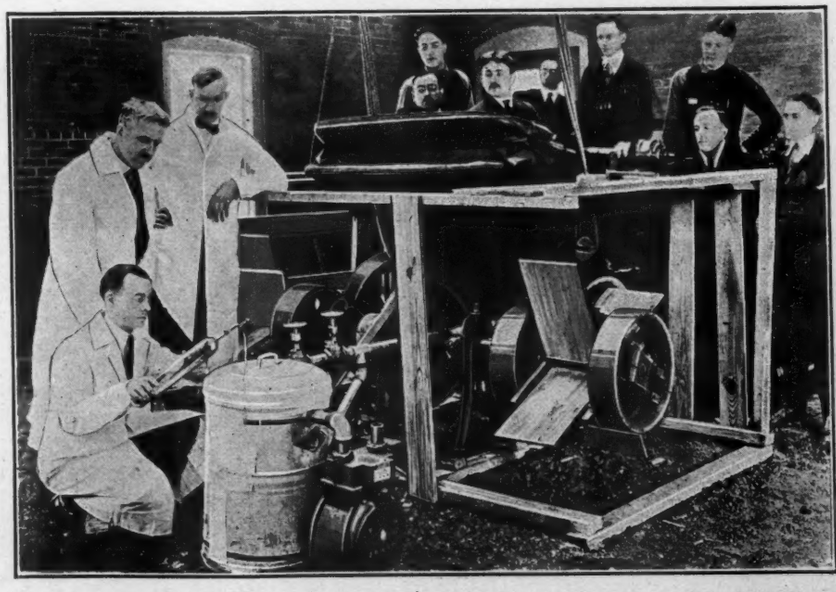
could be inhaled without inconvenience or hurt for a much longer time than would be required to make the journey through the tunnel at the very slowest pace.

We are informed that although carbon monoxide is the cause of more deaths than the total due to other gases, it is, apart from a single reaction, a physiologically inert and non-poisonous substance. The reaction in question is its combination with hemoglobin, the red coloring matter and oxygen-carrying element of the blood. To whatever extent hemoglobin is so combined it is rendered incapable, until the carbon monoxide is again displaced, of taking oxygen from the lungs to the tissues and the organs of the body. In other words, a vital system of internal transportation is hampered; and in proportion to this impediment the distribution of life-giving oxygen is lessened. Again, we must skip many details that are interesting and deal directly with the conduct of the experiments at Yale and the lesson to be drawn from them.

In one series of tests, the subject was placed in a compartment that could be made airtight and which had a capacity of 226 cubic feet; in the second series a chamber having a capacity of 12,000 cubic feet of air was employed. In this was installed a Ford car and several persons were exposed to the variably vitiated atmosphere. When the small compartment was used, measured amounts of pure carbon monoxide were introduced after a subject had entered, and at different intervals the latter shoved his hand through a self-sealing elastic panel so as to facilitate the withdrawal of blood for analysis. Persons submitting themselves for test spent periods of one hour in an atmosphere containing from two to eight, and in one case ten, parts of carbon monoxide in 10,000 parts of air. While they sat and read most of the time, there were a sufficient number of acts—such as turning on an electric fan to insure a thorough diffusion of the gas, standing up to look out of the window for a moment, opening and closing flasks to take air samples for later examination, etc., to correspond fairly well with the activity of a driver of a car. Doctor Henderson says: "When we speak of the absorption of carbon monoxide by a person 'sitting at rest' the condition must be understood as only such moderate rest as just described."

Blood, to the amount of twenty or 30 drops, was drawn from a finger before the volunteer entered the chamber; and .02 cubic centimeter was similarly obtained at the middle of the period and at the end, and usually once or twice during the succeeding three hours. These samples of blood were analyzed for carbon monoxide. After leaving the compartment the subjects were put through various tests to ascertain the effects of the inhaled carbon monoxide. It appears that no one had an appreciable degree of headache after remaining one hour in the chamber, during which the atmosphere contained four parts carbon monoxide or less. With six parts, the effect, if any, was usually very slight. With eight parts there was decided discomfort for some hours, although not enough to interfere with efficient work in the laboratory or at the desk. After an hour, with ten parts, even an exceptionally resistant individual was rather miserable; averse to effort for five or six hours; and could still feel the effects after half a day.

In the case of the experiments in the larger chamber, where the air was tainted by the actual exhaust of an automobile, the disclosures in no wise differed radically from those already referred to; and the net result of the findings was that men, women, and children—including infants and invalids—not to mention soldiers, who might have to march through the tunnel, could in perfect safety breathe for an hour an atmosphere admixed with four parts of carbon monoxide. Tests with dogs and horses revealed a kindred measure of immunity. The researches at Yale, while minimizing the disquieting motor-vehicle investigations at Pittsburgh did not, however, completely neutralize the possible consequences of the unexpectedly large propagation of noxious gas by cars and trucks, and the question still remained whether or not ample ventilation could be assured without increasing the proposed blower



The larger experimental chamber at Yale in which was installed a small automobile. The observers breathed for different intervals various percentages of exhaust gases mixed with the atmosphere.

Courtesy, U. S. Bureau of Mines.

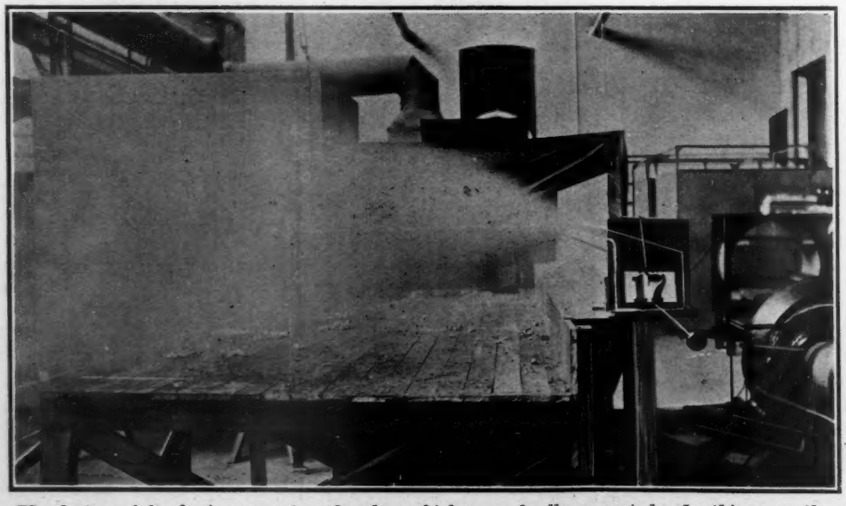
Air-sampling and temperature-recording chamber adjacent to the speedway of the Bruceton experimental tunnel. This station was linked by tubing with numerous sampling bottles placed at different parts of the tunnel for the reception of air during the driving of motor cars. At the right are electrical indicators which were connected by wires so thermo couples located on and in the walls of the tunnel. The object of the latter apparatus was to determine the amount and the rate of diffusion of heat through the tunnel walls and emanating from the internal combustion engines of the motor vehicles.

installation of the air distributing system. The settlement of this problem directly concerned the annual cost of operation. An answer to this query was obtained in a thoroughly practical manner by a second series of investigations.

The first of these studies was pursued at the Engineering Experiment Station of the University of Illinois under the supervision of Professor A. C. Willard and in accordance with a program prescribed by Mr. Holland. There was built at Urbana, Illinois, a half-size trial-duct 300 feet long. This duct was constructed of reinforced concrete and timber, and was patterned along the lines planned for the full-sized duct designed to be located beneath the roadway of each of the tunnel tubes. Under the terms of the contract entered into with the University, the work at Urbana was to deal specifically with the following subjects: first, the determination of the coefficient of friction of air flowing in concrete ducts such as were proposed for the vehicular tunnel; second, the verification of formulae used in computing the power required for moving air through a duct from which air would be drawn off at designated intervals; and, third, the measurement of power losses due to bends in flues, ducts, or airways.

As will be readily grasped, the scope of the tests at Urbana was such as might be expected to reveal how the ventilating air could be effectually distributed and what modifications of design, if any, would be needful to achieve this end with the least possible blower energy. The experimental duct was surmounted and straddled by three reading stations, each of which was equipped with suitable gauges for indicating high, low, and intermediate pressures. Further, within the duct were installed Pitot tubes and Piezometer plates for registering pressures and velocities at various positions in the duct cross-section.

Along each side of the duct, at prescribed intervals, there were ports or outlets. These represented discharge passages by which, in the vehicular tunnel, fresh air would reach both flanks of the roadway; and the openings were fitted with adjustable shutters that would either seal the ports or facilitate regulating the escaping air. Thus, it was practicable to gauge the pressure, volume, and velocity of the air issuing from these outlets. At the admission end of the duct there was placed an electrically-driven blower having a rated capacity of 105,000 cubic feet of air per minute at a pressure of seven inches.



The design of fresh-air expansion chamber which was finally accepted. In this case the discharged air is distributed over a wide vertical arc and is carried the maximum desired distance toward the imaginary roadway center line.

During the earlier tests the farther end of the duct was generally closed and the exhaust air reached the outside atmosphere via the side ports. Under this condition the duct, simulated the proposed method of ventilating the vehicular tubes. That is to say, the ventilating ducts in either of the tubes are not intended to furnish an uninterrupted flow of inbound and outbound air from portal to portal. These ducts will be blocked by bulkheads at the center of the river; and the blower equipment on each bank will therefore take care of only half of the length of the tunnel. Such being the case, the primary experiments were devoted to ascertaining whether it would be feasible to get a fairly uniform supply of air at all points of the duct, and this at pressures that would not be markedly different at stations close to the blower and at those remote from it. It was thought that the first and the middle sections of the duct would have enough air but that the third or last section might show a deficient flow. Contrary to expectations, the most distant stretch of the conduit gave an ample discharge, and this was discovered to be due to the back pressure built up in that area, while the middle division fared worse despite the shorter distance from the fan. This meant that the outlets in the middle section of the duct would have to be larger than those in the third one in order to provide the required volume of fresh air to effect the needful dilution of motor gases throughout the corresponding part of the actual tunnel. This disclosure contradicted the commonly accepted theory applicable to similar cases.

The foregoing researches emphasize not only the errors of prevailing formulae but establish the fact that the coefficient of friction usually employed in connection with the flow of air in concrete ducts, etc., was about 100 per cent. too high. This was a heartening discovery. Previous data had been secured by somewhat modest laboratory investigations, while the scale of the duct used at Urbana was large enough to prevent the mistaken deductions of earlier workers in the field.

Another line of inquiry had to do with the evolution of a type of expansion chamber which would best serve to insure the widest dispersion of fresh air in the neighborhood of the tunnel roadways. Twenty-five different models of expansion chambers were tested at the Urbana Engineering Experiment Station before one was evolved which would give satisfactory diffusion. The accepted pattern is so shaped that air issuing from it at a velocity of 1,000 feet per minute has no appreciable force at a distance of but five feet away, and yet the impulse will carry the air quite to the middle of the driveway. In other words, the fresh air entering from each flank of the tube will meet in the center of the cross-section and provide complete circulation.

The concluding studies at Urbana were di-

Views of Experimental Tunnel and Air Measuring Apparatus

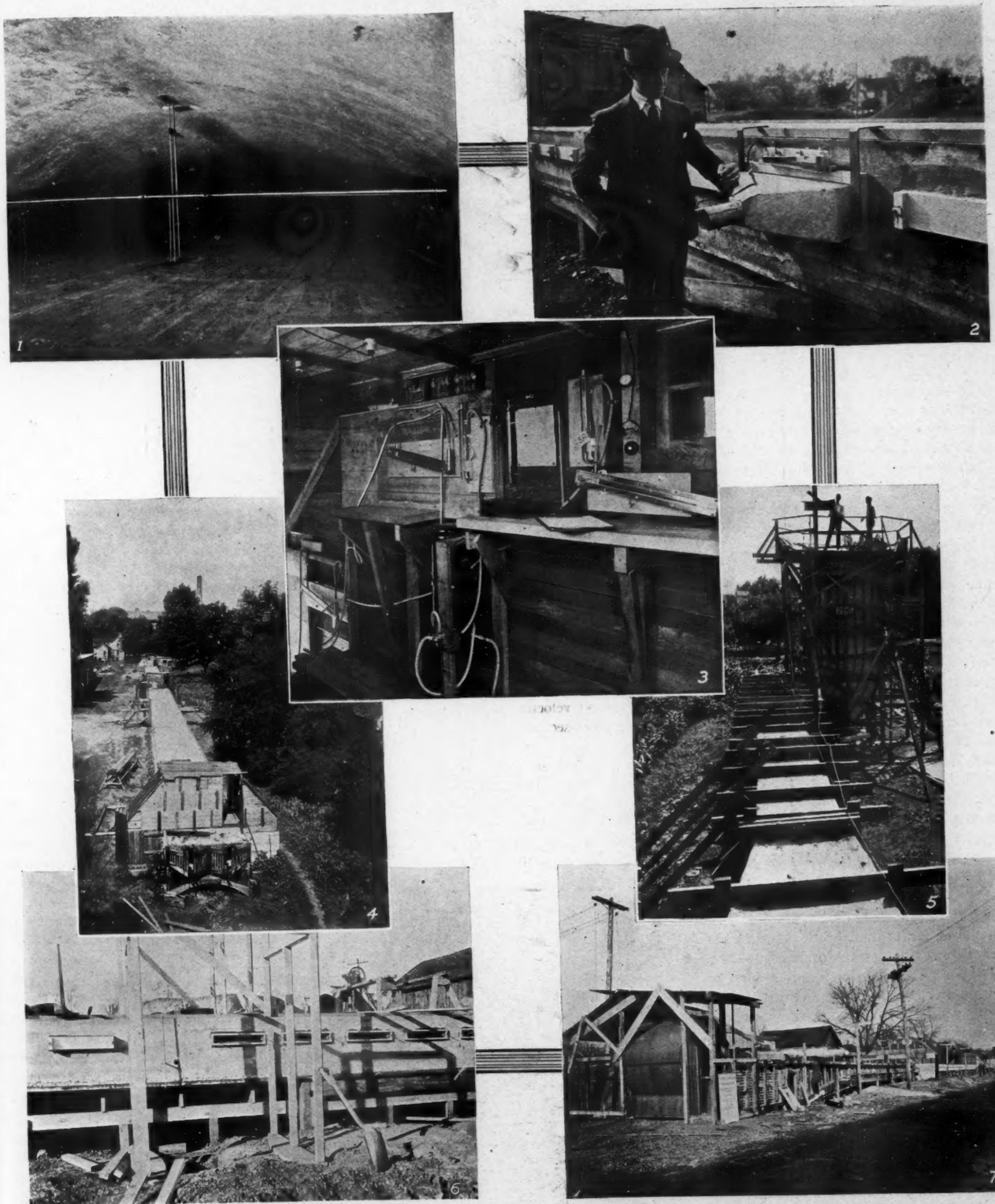
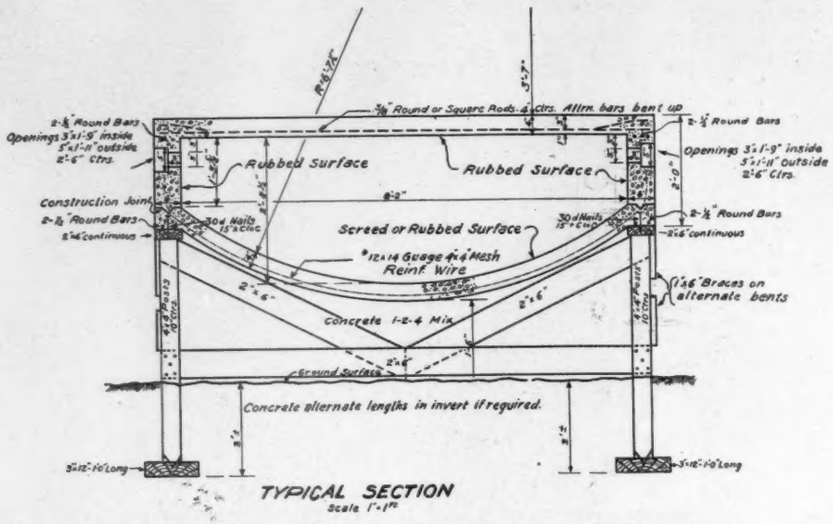


Fig. 1—Interior of experimental air duct at Urbana with Pitot tubes and Piezometer plates in position. Certain operative coefficients determined for the duct under all conditions of service. Fig. 2—View of cone-measuring apparatus by which the quantity of the air flowing from the ports could be determined. Fig. 3—Interior of one of the three reading stations which surmounted the experimental air duct at Urbana. A signal bell at each station made it possible to insure simultaneous and co-operative observations. Fig. 4—General view of the experimental concrete air duct built at Urbana, Ill., for researchers in connection with the Hudson River Vehicular Tunnel. Fig. 5—Combination elbow and connecting flue, full size, which was placed at the outer end of the experimental air duct at Urbana. This elbow typified the junctions which will be made in the Hudson River Vehicular Tunnel between the two tubes and the four ventilating shafts. Fig. 6—Exterior of a part of the experimental air duct at Urbana showing side ports which simulate the passages by which fresh air will be fed into the vehicular tunnel. Fig. 7—The experimental air duct at Urbana seen from the blower end. The fan was operated electrically and was capable of furnishing 105,000 cubic feet of air per minute at a pressure of seven inches.



Typical section, experimental duct, Hudson River Vehicular Tunnel.

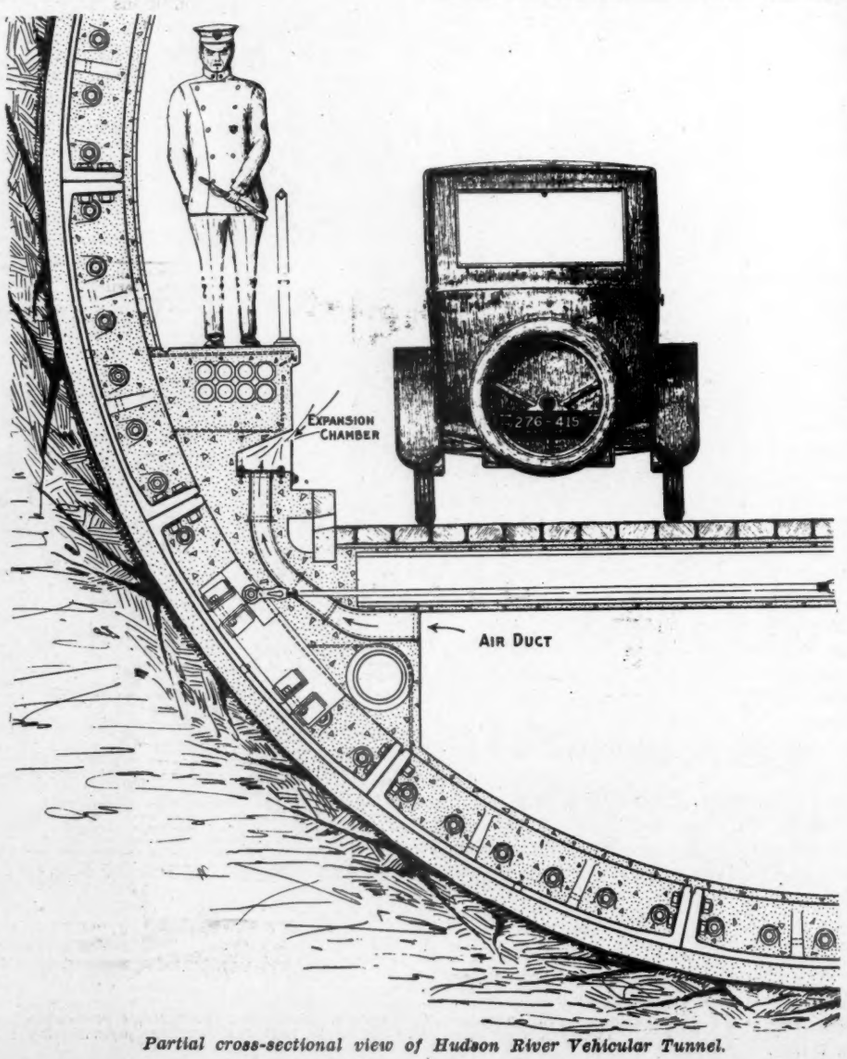
rected to determining power losses due to blowing air through the bends of flues, etc., and with this in view full-sized elbows of several sorts were tentatively tried out before erecting a combination elbow at the far end of of the 300-foot duct. This elbow represented a union such as will be formed where the vehicular tunnel tubes join the four ventilating shafts through which fresh air will be fed downward and foul air will be drawn off and sent aloft to the free atmosphere. In the elbow the air is obliged to make two turns, each of 90 degrees, and it was important that the change of route should not invite any needlessly increased resistance.

There is a well-recognized law that the inner or short radius of a duct shall be equal to the diameter of that passageway. This could not be subscribed to and the desired result realized because of the large diameter of the elbow. The area of that conduit was bound to induce a high coefficient of friction by reason of the lessened velocity of the air stream threading its way through the compound turn, As the textbooks tell us, the coefficient of friction varies with the velocity—i. e., the greater the velocity the lower the coefficient of friction. The technicists solved the problem by interposing a vane or longitudinal partition in the airshaft; and by this agency the single passageway was transformed into two, each of them having a short radius such as would meet the theoretical requirements. This divisioning caused the air to rush more rapidly through the tortuous channels; and the added velocity so diminished the frictional resistance that the impulse power was reduced at the elbow by quite 25 per cent.

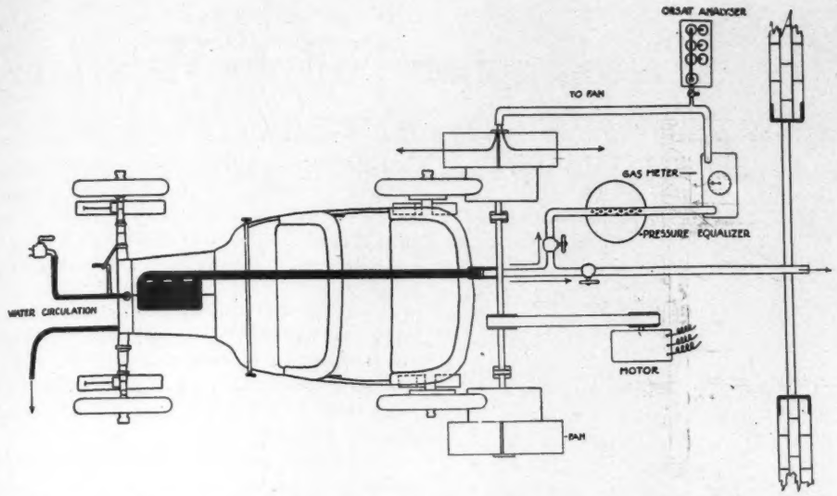
The researches at Urbana, together with the finding at Yale, completely counterbalanced the rather discouraging revelations of the motor-vehicle gas tests at Pittsburgh; and the only ventilating question still awaiting settlement was whether the fresh air should be fed up into the tubes from ducts below the roadways or downward from similar conduits overhead. Once more the tunnel engineers besought the aid of Government experts. It will be recalled that opinions differed as to where the supply and the discharge ducts should be located; and there was much logic in the argument that the engine gases could be disposed of quickest and by the shortest route if they were carried off near their points of origin—i. e., by exhaust ducts running beneath the floors of the tubes.

In order to approximate the subterranean circumstances that will characterize the Hudson River vehicular tunnel, a test tunnel, 130 feet below ground, was utilized. This tunnel, nearly oval in form, was constructed at Bruceton, Pa., in the experimental coal mine of the U.S. Bureau of Mines, and was the result of uniting two existing parallel drifts by curved terminal galleries. Within this tunnel, which has an axial length of 400 feet, was built a timber-and-reinforced driveway having a rectangular cross-section nine feet wide and seven and one-half feet between the floor and the ceiling. Underlying the floor is a duct four feet high and above the ceiling there is another conduit five feet high, and arrangements were made by which either duct could be used at will for exhaust or supply purposes.

At eight stations, set five feet apart, on one of the straight sections of the under-ground speed-way, were hung at different elevations groups of sampling tubes. These were connected by piping with a central station whence air from all of them could be pumped. An interval of half an hour was needed to fill the sampling tubes for testing. The number of motor cars run during the investigations ranged from one to eight, and each of these vehicles also carried sampling tubes—one on top, one at the driver's feet, and a third intermediate



Partial cross-sectional view of Hudson River Vehicular Tunnel.



Plan of the general arrangement of the motor car and apparatus used at Yale in determining the effects of exhaust gases upon groups of volunteers confined in an experimental chamber.

between these extremes. The automobiles were driven uniformly at a rate of ten miles an hour. Chauffeurs and passengers were subjected to examination before and after every trip by physicians and physiologists; and the machines were operated for one-hour periods. Besides exhaust-gas sampling apparatus, each motor was provided with gasoline measuring facilities; and there were air sampling tubes interposed in the exhaust duct at one station, where samples were taken continuously to determine the make-up of the air as it left the tunnel. In brief, care was taken to guard against any possible errors through a comprehensive counterchecking system; and it was practicable to determine the composition of the air at any vertical or longitudinal point in the tunnel.

All told, seventeen ventilating experiments were made at Bruceton—six of them with the fresh air reaching the driveway from overhead and eleven of them with the fresh air issuing from the duct beneath the floor. During these, two runs were made with one car, two with three cars, five with four cars, and eight with eight cars. While it was ascertained that there was apparently no striking difference between upward or downward admission of fresh air, what difference existed was in favor of upward circulation. Further, the developed structural features of the tunnel made the latter course more desirable. On the other hand, the physiologists found that the absorption of carbon monoxide by the blood was less with the rising movement of the air than with the descending flow—the percentage of CO in the atmosphere being the same in both cases.

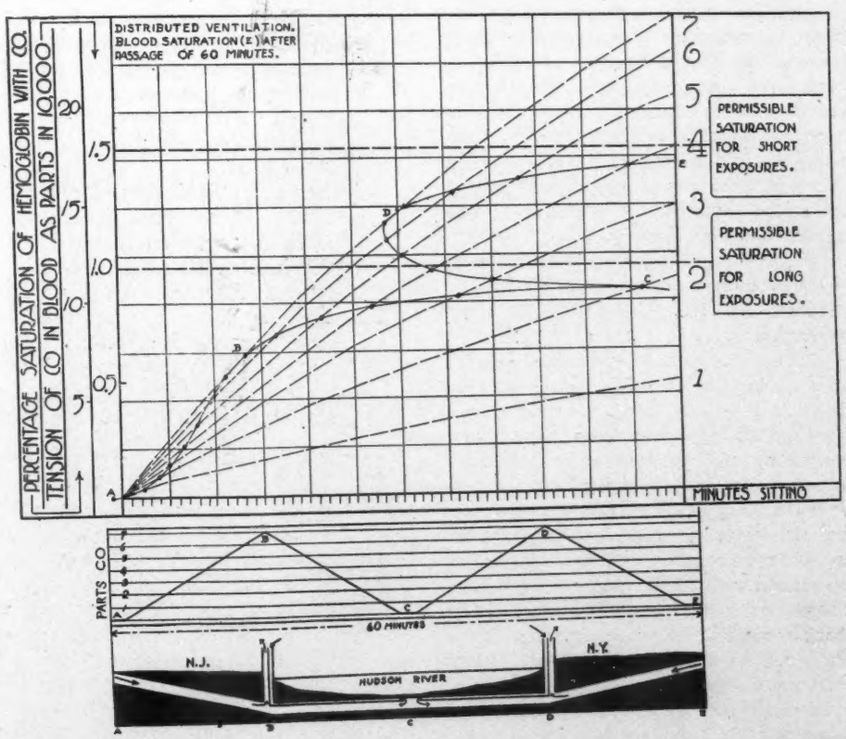
Carbon monoxide, at atmospheric temperatures, is a trifle lighter than the air, and the total average of all the exhaust gases from a motor car—at equal temperature, is also somewhat lighter than the air. Therefore, the hot engine exhaust has a pronounced tendency to ascend when discharged. This is accelerated by the eddy or partial vacuum at the rear of an advancing car and is further stimulated by an inrush of fresh air impelled ceilingward from low-lying expansion chambers. In other words, the noxious gases in the vehicular tunnel will thus be swept toward the ceiling and got rid of before they will have a chance to diffuse and to contaminate seriously the continually changing atmosphere.

The underground tunnel at Bruceton had a heating plant, and being 1,050 feet in from the pit mouth of the mine it was practicable to maintain reasonably uniform temperatures, and to reproduce at will conditions substantially identical with those that will prevail at various seasons within the tubes that are to be driven beneath the Hudson River. It is well worth stressing the fact that the comprehensive inquiries described settle not only how best and most economically to ventilate the tunnel in question, but they provide data of great value for many other engineering undertakings and show wherein the technical manuals of to-day err.

Finally, for the sake of those interested in figures, let it be said that an aggregate of 6,500 horse-power will be required to operate the blowers when the tubes are used to capacity, and this will involve a movement in both of these subaqueous driveways of an average total of 3,500,000 cubic feet of air per minute. To be specific, the flow of air on the up-grades will be at the rate of 293 cubic feet per minute per foot of tunnel; the stream on the down-grades will have a volume of 125 cubic feet per linear foot of tube; and on the level portions of the tunnel the air will have a tide of 225 cubic feet per minute. This distribution will suffice to prevent the dilution of gas exceeding four parts of carbon monoxide in 10,000 parts of air.

At the Pacific Experiment Station, in the study of the purification of copper sulphate solutions, experiments will be undertaken in the removal of iron and aluminum from the solutions by hydrolysis with limestone and later with other hydrolysing agents.

Investigative work on helium recently conducted by the Bureau of Mines may be divided into the following heads: Helium production at Petrolia, Texas; investigation of known and of probable areas of helium-bearing gas; helium storage; helium repurification after use in balloons; and investigations of gases and liquids at low temperatures, with particular reference to obtaining data for use in perfecting methods for separating helium from natural gas by progressive selective liquefaction.



Graph illustrating percentage saturation of hemoglobin with carbon monoxide in relation to the atmosphere at different sections of the Hudson River Vehicular Tunnel.

Russia's Plight—Why Trade Resumption Fails to Materialize

A Survey of Political and Industrial Conditions Showing the Results of Progressive Curtailment in Production—Obstacles in the Way of Trade Re-establishment

By PROF. PAUL N. MILIUKOV

Former Minister of Foreign Affairs in the Russian Provisional Government

IN THE COMPRESSED AIR MAGAZINE of August, 1920, I read an article on Russia written by an eye-witness and testifying to the extreme breakdown of the economic and social life, especially in Petrograd. The author of the article stated that he could not see how the Bolsheviks could exist any longer after having exhausted all their resources. The picture painted was entirely a true one. Since that article was written almost two fateful years have passed. How then were the Bolsheviks enabled to live through this period, and how much longer can they exist on a system expressing itself solely in consumption, without producing anything else but what is strictly necessary for their self-defense?

The answer is twofold. In the first place, in the first part of 1920 not all of Russia had yet been exhausted. During that year they took from the "White" generals, Kolchak, Denikin and, later on, Wrangel the most fertile provinces of Southern Russia, Caucasia and Siberia. These are the grain-producing provinces of Russia, and during 1920-1921 the Bolsheviks lived on the agricultural products of these newly-acquired regions. But another side of the answer is that the Bolsheviks, after having spent all the popular income, have been living on the capital. They have been simply destroying Russia and bringing her economy back to the primitive stage passed some 60 years ago. Bolshevist Russia is literally dying out.

The Russians, a young race, were always at the top so far as their birth rate was concerned. Their number was increasing before the War at the rate of 2.8 millions a year. What is the situation now? One can judge from the following figures:

(Per thousand)	1900-1909	1919
Births	46	13
Deaths	29	75
	+17	—62

Thus, instead of a yearly increase of about two per cent., we have now a yearly decrease of about six men out of every hundred. But in 1919 the food shortage was only beginning to be felt. It was in 1921 that the great unexampled famine broke out, and fifteen millions may die in the famine stricken area alone. This already will give a ratio of eleven deaths to every hundred of the population.

The worst of it is that famine has become a continuous phenomenon in Russia. It cannot be stopped or prevented. This year it was explained by an exceptionally dry season. But such seasons recur regularly in Southeastern Russia. Before the War the State and the local organs of self-government knew how to palliate the resulting conditions. Now it is impossible. Not only are there no more stores of grain, but even if there were surpluses in other provinces the grain could not be easily transported. The chief point is that there can be no surpluses. The peasants have not wanted to sow except to satisfy their own needs, and the planted area now forms only about a half of what it was before the War.

Moreover, on this remaining half the productivity is exceedingly lowered. This is due to the fact that there are no agricultural implements, the live stock is almost entirely destroyed and, accordingly, there is no manure, while mineral fertilizers were always imported from abroad. That is why, even if there will be good crops in Russia, there still will be a shortage of grain and Russia will be unable to feed herself.

Under such conditions, the situation of the Bolsheviks is speedily becoming quite desperate. They cannot live on the taxes, because the taxation, in spite of all the exertions to increase it, covers much less than one per cent. of their expenses. It is estimated that in 1918 the deficit in their budget was about two-thirds of the whole. In 1919 it was more than three-fourths. In 1920 it was already almost nine-tenths of the budget. The gaps were covered with paper money. But the result was —an inflated currency and an enormous increase in prices. No adjustments of wages can keep pace with the increased prices. In 1918 the average wage was between 500—1,000 roubles a month. In 1920, according to the article in the August issue of the COMPRESSED AIR MAGAZINE, it was 5,000 to 8,000 roubles. Now, at the end of 1921 the average salary was 600,000 roubles a month. But, it did not amount to much because at the same time flour cost 16,000 roubles per pound, meat 18,000, sugar 50,000, butter 60,000, etc. At the same time, the rate of exchange was more than 200,000 roubles for the dollar. Accordingly, a working man received a monthly salary of $3.00.

It is obvious that paying with paper money was useless. The State had to pay with grain. But where could they get the necessary grain? We know that the crops were speedily diminishing in quantity. The stores of grain which the peasants had carefully concealed were discovered and taken from them by force. The longer this process of requisitioning continued, the more difficult it became. In 1920 the Commissariat of Food Supply succeeded in requisitioning from the peasants about 350 million poods (pood—36 lbs.). In 1921 they expected to collect 240 million poods by the newly-introduced "tax in kind," which they substituted for the requisitioning by assessment. But they were unable to collect that much, while their minimum need for feeding their army, their officials and such number of working men as they needed for themselves was estimated at 400 million poods..

We have now a very interesting estimate for 1922 which shows that the Bolsheviks despair of collecting even as much as they collected in 1921. They expect now to get only 160 millions from the "food levy." What about the rest of the minimum? They have to feed, at least, their 3,275,000 officials, 4,100,000 work-

THE AUTHOR of this article, Professor Paul N. Miliukov, well known Russian scholar and statesman, is not a stranger in the United States.

Aside from the numerous books he has written, which have appeared in many languages, he has lectured frequently before American audiences, and several years ago he served with distinction as exchange Professor at the University of Chicago. In Russia he was a Professor at the University of St. Petersburg, and was also a historian of note.

Although a Democrat at heart, Professor Miliukov considered that, historically, Russia ought to proceed along the lines of evolution in other countries, viz., establish a constitutional Monarchy with accent on the constitution.

The political party in which he played a very prominent role was called "Kadet" for short, being an abbreviation for the constitutional Democratic party, to wit, the party advocating the idea of a constitutional form of government as opposed to the Absolutism of the Czar.

When the Revolution of March, 1917, broke out, Professor Miliukov was entrusted with the important post of Minister of Foreign Affairs. In this capacity he personally gave out the first official notice to the outside world of the downfall of the autocratic Imperial government.

ing men in transportation and industry and, probably about 1,000,000 Red soldiers. They obviously cannot. They must either decrease the number of their pensionaries or import grain and manufactured goods to be exchanged for grain. The news has already been published in the "Red" newspapers, that they have reduced by two and one-half millions the numbers of such as are in their civil service. Another alternative brings them to the idea of a foreign loan and of restarting foreign trade. They are badly in need of both, but it would be naive to think that their motive is serious economic reconstruction. They will spend any loan granted them to cover their current expenses. And then . . . they will ask for more.

In September, 1921, they tried to negotiate through Dr. Nansen a loan of £10,000,000. On October 6, the Brussels session of the International Russian Relief Commission answered them that no credits could be granted "until economic conditions have been realized guaranteeing normal production within Russia and until confidence has been sufficiently restored for foreign exporters to send their goods to Russia." Now, the sound basis for "normal production" is private property and private initiative. It cannot be realized under the Bolshevist system of what they call "State Capitalism" or even under that "State Control" to which Mr. Lenin recently tried to confine his "State Capitalism." Only a few, and not important, concessions have been granted up to now, such as the running or renting of small concerns (chiefly flour mills and sausage factories have been up to now rented), the restarting of free local trade, etc.

To restore the confidence of foreign exporters, a sound balance of trade is needed, as well as a good budget and currency. I have already described the state of the budget and currency. No balance of trade is possible so long as there is nothing to trade with. In March, 1921, Secretary Hughes rightly stated in his answer to Mr. Samuel Gompers, that, although there are no legal restrictions on direct trade with Russia (since July 8, 1920), and "both American and European goods have been sold to Russia, but the volume of trade has been unimportant, due to the inability of Russia to pay for imports. And, indeed, the most important items of Russian exportation do not exist any more." Far from being able to export cereals,—which constituted about a half of Russia's pre-war export,—Russia needs grain for herself, and the United States' appropriations for buying grain cannot be repeated every year. The production of flax, which was another important item in Russia's foreign trade, has dwindled to one-tenth or one-twentieth of the pre-war amount; instead of the 35-40 million poods of the pre-war crops only five and two millions were produced in 1919 and 1920 respectively. The output of sugar decreased from 105 million poods in 1914 to five million in 1919 and six million in 1920.

The state of Russia's industry is still worse than that of the production of raw materials. The production of coal and iron is entirely at a standstill. In Russia the "starvation minimum" for fuel is considered to be ten to eleven million cubic "sagens" (one cubic sagen =343 cubic feet). The total amount of fuel under the Bolsheviks is less than one-tenth of the minimum required. It diminished at the following rate (in millions of cubic "sagens"):

1916 (War)	1917 (Revolution)	1918 (The Bolsheviki)	1919 (The Bolsheviki)
17	13	0.9	0.7

The amount of metal required by industry in 1919 was 113 million poods. Less than one-third (37 millions) was provided, but under the conditions of decreased productivity of labor even that amount was not used; the amount of metal actually used was one-half of it.

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Professor Paul N. Miliukov.

The cotton industry had really formed the backbone of the Russian rich "bourgeoisie." Home-grown cotton (Transcaucasia, Central Asia) had been gradually taking the place of imported cotton (American, Egyptian, East Indian and Persian). But the area sowed in cotton in Turkestan was reduced as follows (taking as 100 the figure for 1916):

1916	1917	1918	1919	1920
100	66	14	15	19

The Bolsheviks had "nationalized" (in 1919) a total of 6.9 million spindles and 162 thousand weaving looms. After eight months only 300 thousand spindles (four per cent.) and eighteen thousand weaving looms (eleven per cent.) were actually working. Most of the concerns were closed and the others worked only a part of the week. In 1921 two million spindles and 48 thousand looms were expected to work, but under the disintegrating conditions in the production of cotton it was hardly possible to achieve even that amount of work.

The Bolsheviks then addressed themselves to foreign capital to restart their industry. It is important to note the answer they received from a group which already had possessed very important mines in Russia before the Revolution: the "Russo-Asiatic Consolidated, Ltd." After protracted negotiations both in London and in Moscow (September, 1921), Mr. Leslie Urquhart, a member of the Board of Directors, who knows Russia thoroughly—and who, of course, was very much interested in restarting their concern—wrote to Mr. Krassin that he preferred to leave things as they were, because no possibility of running the business was found to exist under the present conditions in Russia. Under the new system," Mr. Urquhart stated, "taxes have been

Piling salt at the mines at Solenin, Russia.

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A crowded thoroughfare in Petrograd showing Russians trading by barter. The action is caused by the unsettled conditions of the railroads and such occurrences result in prevailing primitive methods.

abolished, the mining, factory, customs, forest and railway laws and regulations, in fact, all previously existing authorities have been destroyed, and nothing but incomplete Decrees and instructions which are issued daily have taken their place.

Further, the Communistic system does not recognize any obligations between individuals and therefore no contract or obligation between two persons can be enforced; nor does the State itself recognize any obligation to individuals or subjects. . . . This extraordinary position, the absence of all laws and regulations, dominated as you are aware the discussions all through the negotiations. The suggestion made by the Commission (for Foreign Concessions) that questions in dispute or of civil law should be referred to the Courts of Revolutionary Conscience, was impossible of acceptance. . . . With the abolition of the Code of Civil Laws and all the legal authorities and regulations which govern the political and economic life of a nation there can be no justice. As long as the Communist Party controls the Soviet Government, the Third Internationale, the Che-Ka (the secret police for political espionage and prosecution)* and the professional Unions, any one of these instruments of the Communist Party may render inoperative any agreement which may be concluded with the Soviet Government."

Mr. Leslie Urquhart hit the point. The only right conclusion which can be drawn from his thoroughly business-like statement is that which Secretary Hughes formulated in his note of March 25, 1921, on the subject of official trade negotiations with Russia. "It is idle," he said, "to expect resumption of trade until the economic bases of production are securely established. Production is conditioned upon the safety of life, the recognition by firm guarantees of private property, the sanctity of contract and the rights of free labor."

Elementary as these conditions are,—and they were in existence in Russia even under autocracy,—they cannot be conceded by the Bolsheviks. Their concession would for the Bolsheviks be equivalent to self-destruction, as these conditions imply the rejection of the very basis of their arbitrary rule. One must not forget that their aim is to keep in power until the materialization of the world revolution. Accordingly, they can grant only such concessions as do not interfere with that basic aim.

An entirely different stand was taken by the Supreme Council in their invitation of the Bolshevist representatives to Genoa, in January, 1922. The Supreme Council seems to have reconciled itself to the state of things as they are in Russia. They cover their retreat with a good and sound principle which, in another sense, has always been followed by America: "It is the right of each country to choose for itself the system which it prefers." They infer from this that they have no right to dictate to the Bolsheviks "their regime of property, their economy and their government." They only want that the "foreigners" who will be willing to provide the capital for Russia should "have a certitude that *their* property and *their* rights will be respected, and that *their* contracts will be executed "with impartiality."

In other words, an exceptional status must be recognized for the foreigners, in the midst of universal lawlessness and chaos. This would put Russia in the condition of old Turkey or old China. The result could only be to introduce in Russia new "capitulations" and "extraterritoriality." At the back of that attitude there can only be that scheme of exploitation of Russia as a colony which is generally imputed to Germany and in particular to Mr. Hugo Stinnes. Rumors of large concessions to be granted on that basis are rife, and this is what makes the businessmen of other countries uneasy.

I think they need not agitate themselves. I have tried to explain why no serious business is possible in Russia under the present conditions. I must add that attempts to restart it on the part of the foreigners at the expense of the Russian people can only foster ill-feeling against the foreigners. It is true that each country has the right to choose its government by itself. But just this right is denied to the Russian people under the Bolshevist system.

The present government is not based on any form of popular election. No free elections to a representative assembly are admitted by the Bolsheviks. As soon as there is a government recognized by the people, the foreigners are welcome to come and to conclude any arrangements they like. Foreign capital will be badly needed to restore Russia to its feet. But such arrangements as can be entered into now by the Bolsheviks are certain to be bitterly resented, and they will hardly be recognized by any government of future democratic Russia.

Thus far America's policy, from the point

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While hundreds of children starve in the cities, these orphans of Soviet Russia have been taken into the country where food is more plentiful. They are playing in the sand.

*According to the latest news, the Che-Ka is abolished and substituted by a special political department at the Ministry of the Interior. It still remains to be seen whether this reform changes things materially, or whether it is just a change of names.

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A priest and a student in Petrograd, reduced to desperation by want and cold under Bolshevist rule, were compelled to steal wooden paving blocks from the streets of the city to provide warmth for themselves and their families. The priest is shown at the left helping to push the cartload of blocks. Under the waste of the Reds, even houses were torn down for fuel.

of view of that democratic Russia, has been the best and the most sound to follow. Russians of all parties are as thankful to America for the great help she is rendering the Russian *people* as they are suspicious concerning other foreigners. Any step towards the recognition of the present rule will only increase that suspicion. That is why, in the long run, the American policy is also the most business-like and, as things are not likely to change under the Bolsheviks and as their end is near, I do not find any reason for changing this policy just when it has begun to bear its fruits.

DE-AERATING THE WATER FOR TRANSMISSION

IN DISCUSSING the de-aeration of solutions before the Chemical, Metallurgical and Mining Society of South Africa, Thomas B. Stevens drew attention to the work that has been done in Western Australia in connection with what is known as the Coolgardie water scheme. The water is pumped from Nundaring to Kalgoorlie, a distance of 350 miles, through a 30-inch diameter steel pipe; in traveling this distance it is pumped eight times Early in the life of the main there was a rapid increase in friction, and the inside of the pipe became heavily coated with rust nodules. A committee of experts who investigated the trouble advised that lime be added to the water, and also that it be de-aerated. The addition of lime alone was first tried and was found to be inadequate. A de-aeration plant was then installed, and this has been so successful in stopping the corrosion that the use of lime has now been discontinued. The de-aerator is of the mechanical type, the water being sprayed into a tower and subjected to vacuum, 90 per cent of the dissolved oxygen is extracted, and the remaining ten per cent is found to be absorbed in the first 30 miles of pipe. The water as delivered to the mines at Kalgoorlie shows no oxygen by the alkaline pyrogallate test. **The amount of water delivered is 2,000,000 gallons per day.**

WATER-POWER DEVELOPMENT IN SOUTHWESTERN STATES

Among the many projects now under consideration in the southwestern states for the development of water power, says *Popular Science Monthly,* one of special interest is actually under way in Arizona. The building of a dam in the Grand Cañon, above the intersection of Diamond Cañon, is being promoted by a number of copper companies. The power developed, approximately 150,000 horse-power, will be distributed throughout the state, especially among the mines of the southwestern part, which are now dependent on fuel oil and coal, the cost of which is constantly increasing. Another project, under consideration in southern California, is the construction of dams in Boulder and Black Cañons that, besides power development, would impound so much water that millions of acres of now idle land could be made arable by irrigation.

AERATED CONCRETE

CONCRETE IS A building material which already has become of the greatest importance. The universal use of reinforced concrete in every kind of construction, has brought forth a galaxy of mixing and conveying machinery of various degrees of perfection. All these mixers, however, merely serve to mix sand, gravel or crushed stone with cement in proportions to bring out the desired strength of the concrete.

A cross section of a sample of concrete from a mixer, when subjected to minute observation, will show that many grains of gravel or parts of crushed stone are not entirely enveloped by cement; that there are minute surfaces which are contiguous to one another without being bound by cement, and this naturally tends to diminish the strength at these points.

To improve concrete mixing a new process, named by its inventor, Mr. Sprenger, Aero Batidor (air whipped) employs the "aerated concrete" mixer, according to a recent report in *Concrete.*

The principle of this new machine consists of projecting a current of air saturated with the binding material, cement, into a falling mixture of moistened sand and gravel, by which means each particle of the ingredients is completely enveloped and covered by cement.

The apparatus consists of an inclined cylindrical mixer which may rotate on carrying rollers. In the upper part of the cylinder is located the distributing spout for sand and gravel, fed by a bucket elevator. Water is sprayed from a tank with adjustable nozzle onto the ingredients in such manner, that they are thoroughly moistened in falling from the spout.

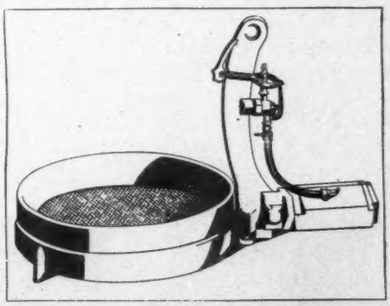
In the opposite end of the cylinder is a cement hopper with adjustable opening delivering the correct amount of cement. A current of air is blown across the cement, blowing the latter against and through the ingredients falling from the opposite end of the cylinder, whereby every grain of the moist sand and gravel is enveloped in cement and the finished concrete is poured into a barrow or car as usual.

NEW VIBRATOR RIDDLE

INCLUDED in new air operated devices recently announced is the Branford Vibrator Riddle, shown in the accompanying illustration. This device is manufactured by the Malleable Iron Fittings Co. and is for use wherever materials are to be sifted and compressed air is available.

While primarily designed as a foundry equipment it is stated it may be used anywhere for sifting. For instance, concrete workers may use it to advantage for removing stones and coarse material from finishing cement.

The device is adjustable and will take from sixteen-inch to 20-inch riddles. It is also



Air operated riddle for use in foundries and other industries.

claimed to be economical in the consumption of air, more so, than older types. The mechanism is enclosed so that no dust or dirt can reach the operating parts. A speed of 1,800 vibrations per minute is attained with this machine. It also tilts back when empty carrying all unsifted material to the back of the riddle. The riddle lifts out by hand, there being no clamps. It can be hung from track or on the wall, over every molders sand heap, taking up no room on the floor.

Bradley Stoughton, formerly Secretary of the American Institute of Mining and Metallurgical Engineers, was elected president of the Yale Engineering Association at the annual meeting on February 2, 1922.

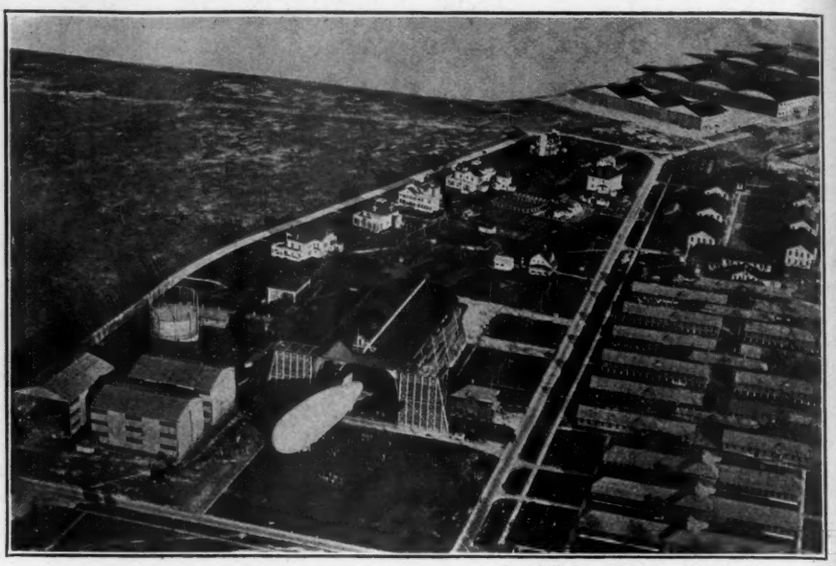
HELIUM'S FIRST USE IN AVIATION

THE CATASTROPHE which befell the U. S. Army Dirigble *Roma* on the 21st of February, shocking as it was, need not be lastingly disheartening. In a way, the loss of that airship merely added emphasis to the hazards incident to the use of hydrogen as the lifting medium. It is inevitable that lighter-than-air craft will have an important part to play both in military and in commercial aviation; and their widened adoption will depend largely upon the steps that may be taken to provide a non-inflammable substitute for hydrogen. Fortunately for us, nature has come to the rescue; and it now rests with Congress to provide the needful funds to extract a sufficiency of helium to meet the demands of our present and potential fleets of the air.

In a previous issue of COMPRESSED AIR MAGAZINE we described in some detail the methods employed by the U. S. Government authorities at the several plants erected in Texas for the recovery of helium from natural gas. It will be recalled how conspicuously compressors figure in the extraction processes utilized at those various establishments. We are now able to depict the actual application in aviation of that light and incombustible gas.

For the first time in history, a dirigible rose from the ground on the 5th of last December under the buoyant impulse of helium and made successfully a round-trip flight from Hampton Roads, Virginia, to Washington, D. C. The U. S. Navy blimp C-7 was the craft signalled out for this memorable demonstration; and her journey to and from the National Capital was accomplished in the course of the day and without a hitch.

Reaching Washington, the C-7 circled over the White House, the Navy Department, and the Capitol, and then crossed the eastern branch of the Potomac and settled to earth at the Anacostia Naval Air Station, where she was inspected by members of the army and navy air services and by experts of the Bureau of Mines who had had much to do in the development and operation of the wartime experimental helium plants at Fort Worth and Petrolia, Texas.



© "Official Photograph U. S. Navy"

The U. S. Navy blimp C-7 leaving its aerodrome at Hampton Roads for an experimental flight to the National Capital and return. On this occasion the dirigible was inflated with helium, and was the first aircraft of any kind to be made buoyant by the use of this non-inflammable gas.

The C-7 was manoeuvred to the ground and sent aloft again without "valving." That is to say, she was handled with her full measure of buoyancy and without discharging any of her lifting gas. In short, she was controlled in the air entirely by the action of her rudders in virtually the same way but in the reverse order of a submarine. The fact that she did not have to expend any of her helium in descending to *terra firma* is of importance, because this gas is far more costly than hydrogen which is commonly used for the inflation of the gas bags of lighter-than- air vessels.

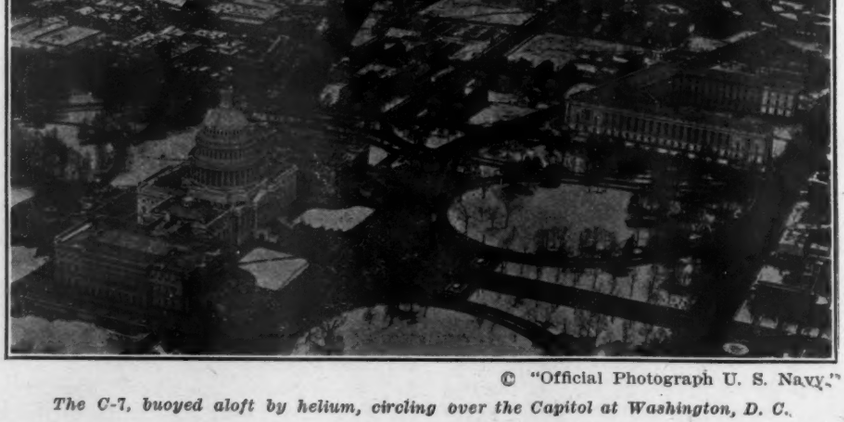
Helium, unlike hydrogen, diffuses more slowly through the enveloping fabric of the gas bag; and it seems that the C-7 had as much of this precious gas within her bag upon her return to Hampton Roads as she had at the start. In time, of course, the external air works its way in through the rubberized texture, displaces a measure of the helium, and reduces the buoyant value of the remaining gas.

It is the usual practice, when hydrogen is employed, to expel the depleted hydrogen and to fill the envelope afresh with full-strength gas. This does not entail any serious sacrifice because of the relative cheapness of hydrogen. This course, however, cannot be permitted in the case of helium, which involves an outlay of anywhere from $56 to about $150 a thousand cubic feet.

Accordingly, the U. S. Bureau of Mines has developed repurification apparatus which can deal with helium that has been diluted by admixture with air, separate it from the air and make it fit again for aviation. Some weeks subsequent to the C-7's trip to Washington her gas bag, so we are told, was deflated and the remaining helium subjected to this revivifying process. This procedure answers a question frequently asked, namely, "What becomes of the helium in a balloon or dirigible when it is no longer buoyant enough for service?" The repurification treatment, like the original extraction from natural gas, depends, in part, upon work done by compressors.

It has recently been announced by Doctor H. E. Howe, of the National Research Council, that we have natural stores of helium in this country sufficient to meet our defensive needs in aviation for quite a score of years, and have, besides, a plenty for certain industrial purposes. As he expressed it, "The United States has a veritable 'corner' in this most powerful gas, and can manufacture an almost inexhaustible supply, whereas all of Europe cannot obtain enough of it to fill a single balloon."

The Bureau of Mines is now engaged in experiments looking to the storage of helium in the chambers or galleries of abandoned mines. One such reservoir has been created by lining with cement and sealing the drift of a disused coal mine not far from Pittsburgh, Pa.



© "Official Photograph U. S. Navy."

The C-7, buoyed aloft by helium, circling over the Capitol at Washington, D. C.

The Butte System of Square Set Stoping

Details of Method Including Timbering for Supporting Badly Faulted Ground and Also Procedure for Recovery of Caved Stopes

By H. L. BICKNELL

SOME OF THE ore bodies in the Butte district are of such shape and size, or the walls containing the ore bodies are so broken by faults that it is not practical to mine by either the open rill method or the timbered rill method of stoping. For this type of stopes the timbered or square set stoping method is used. Fig. 1 shows a square set stope in a narrow vein after the preliminary development has been done and the stope has been carried toward the upper level.

Development

The distance between levels varies from 100 feet to 200 feet, depending upon the size of the veins, their condition and the cost of running the crosscut to intersect the vein. In case the vein is some distance from the shaft a larger lift is usually made in order to cut down this preliminary development cost.

The drift is driven in the vein, leaving offsets into the footwall every fifth and sixth set of advance, to be used later as chutes and manways for the raises or stopes as the case may be. When the work has been advanced far enough ahead, raises to connect with the level above are started in every third or fourth of these offsets. The usual practice is to keep accurate account of samples of each set advanced in both the raises and the drifts so that a fairly accurate estimate of the size and grade of the ore in each block can be made.

When the raises have been driven far enough upward so that work in the stope between the first and second raises will not conflict, the stoping is started, usually from the first and most advanced raise and on the first floor. The first and second floors are mined, mucking the broken ore down through stop boards in cars in the drift. These floors are timbered, as the mining is completed, with square set timbers, using round timber for the sets between offsets of the drift and 10x10 in. square timber for the two sets over the offsets. After these two floors are mined between the two raises and all of the rock is cleaned out the sheeting is put in place over the drift caps and the intermediate chutes and manways are built. This completes the preliminary development of the stope.

Stoping Operations

A floor of 4x10 in. lagging is laid over the caps of the second floor before mining of the third floor is started. The first set in the third floor, next to the raise is usually drilled from below, blasting the ore down on the second floor and wheeling it to the chute. When the loose rock is barred down in the space opened by the blast for the set on the third floor, timber is hoisted either through the raise or the new intermediate manway, blocked in place and lagged over with 4x10 in. lagging. The third floor is then advanced along the stope toward the raise at the other end.

SQUARE set stoping is required where ore bodies are of such shape and size or the walls are so broken by faulting that it is not practical to mine by either the open rill or timbered rill methods.

In previous issues of Compressed Air Magazine a general description of the rill stoping methods used in the Butte mining district was given in detail. The author in this article on square set stoping completes the whole subject of stoping methods as used in this district.

Each set is timbered before blasting for the next set ahead as the back of the ground is apt to "slack" and "sluff off" if it is left unsupported by the timber for any length of time. All of the rock broken on the third floor is dropped to the second floor and trammed to the chutes in wheelbarrows. The waste rock mixed with the ore is picked out when mucking and thrown down on the sheeting over the first floor.

When the mining of the third floor is advanced beyond the first intermediate chute and manway another floor can be started from the first raise and both places can be worked at the same time.

The timber used in the first few floors of the stopes is hoisted by air driven hoists from the level below, until the first raise has been finished and holed through to the level above. Usually the stope has been mined up to about the sixth floor by the time that the raise has been holed. From that time on it is much cheaper and faster to lower the timber down the timber slide of the raise from the level above.

Stopes of this kind must be kept fairly well filled as the mining is carried upward. The best practice is to keep the stope filled up to within one or two floors of the mining floor at all times. As there is usually not enough waste in the ore broken to fill the stope properly, waste is transferred down from the level above, through the chute of the raise which has been holed to the upper level. This is done by building a temporary chute mouth in the chute near the top of the stope and tramming the waste by car to the part of the stope where filling is needed.

In some cases where the stope is isolated or filling cannot be transferred from some other part of the mine, waste inclines are driven into the footwall to procure the necessary waste. These raises are usually pitched at about 45 degrees so that the waste will run

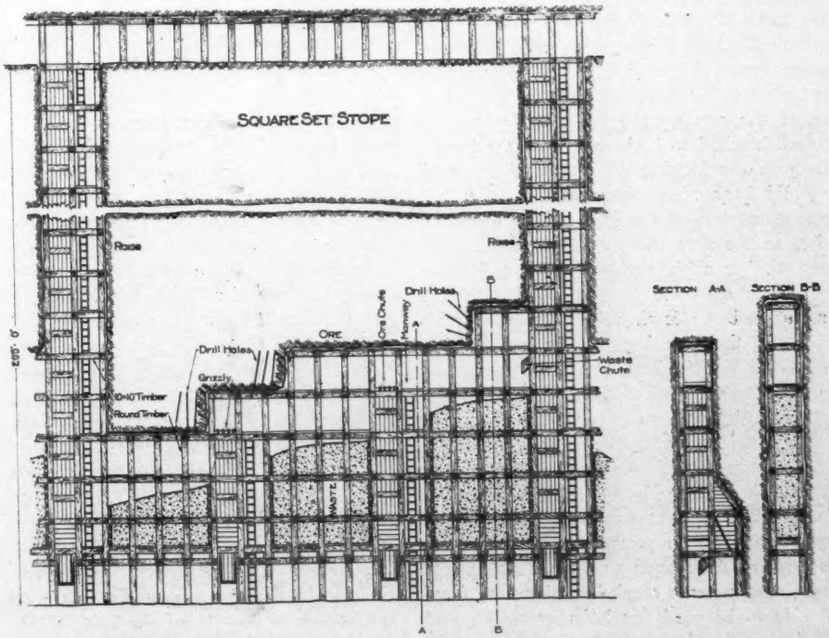


Fig. 1—Showing the details of timbering and mining in narrow stopes.

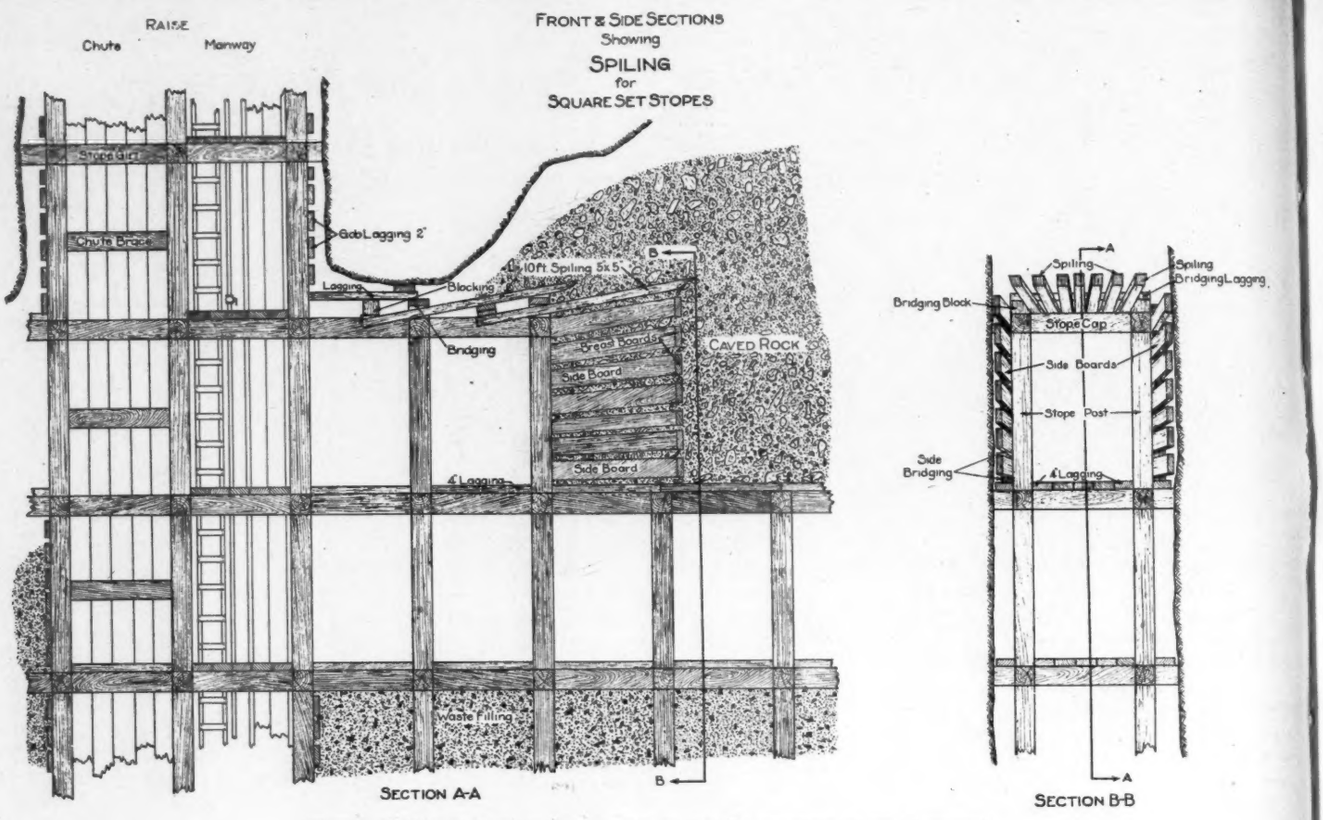


Fig. 2—Spiling as used in narrow stopes for the recovery of caved ground.

down into the stope without mucking. This is not considered good practice, as where the wall is blocky and broken by slips, it is weakened by these waste raises and is very apt to cause heavy ground later on in the development of the stope.

Timbering

The timber used in the stopes is of two kinds. Square 10x10 in. timber is used in all raises and in all chutes and manways, while round timber, undressed is used for all other sets. The round posts vary from about nine and one-half to eleven inches in diameter. Lagging, 4x10 in., and five feet four inches long is used for flooring and for back lagging of the sets on the top floor. The sets are well blocked to both walls and the breast, and from the lagging on top of the sets to the solid back above over each post. Care must be taken to have butt blocks from the timber to the side walls made of good sized round timber with regular cap framing on one end in order to fit the framing of the standing timber, allowing the girts of the next set to fit the framing of the set already blocked. When the back breaks high over the timber the set is blocked, lagged and then the back is caught up with cribbing made of 4x10 in. lagging to prevent caving and sluffing.

Ladders are carried on one side of the manways as the stope advances. These ladders are carried up straight for three sets and then offsetted in order to promote safety. On the other side of the manway a timber slide made of two-inch timber is carried up along the footwall side to be used for hoisting timber and tools during the time that the first five or six floors are being mined and for lowering the drill steel from the stope.

Drilling can be done in two ways. When the holes are drilled into the breast from the floor being mined it is called "breast stoping." The blocks and lagging are removed below the breast so that the ore will fall to the floor below when blasted. A round of from five to seven, six foot holes, will usually give sufficient room for a set of timber. If the holes are drilled from the floor below it is necessary to drill five, seven or eight foot holes. This is called "back stoping."

In all of the stopes, all open manways, sets that are not floored, and any place where a man might fall, are surrounded by guard rails made of 2-in. timber and placed about four feet above the floor. Cross-overs in all of the manways also have a guard rail between the ladderway and the hole left for the timber slide. The tops of all waste chutes and manways holing to the upper levels above the stopes have guard rails and in addition grizzlies are used on top of the chutes.

Drilling is generally done with Ingersoll-Rand Type CC-11 and CC-21 Stopehamers having air feed and anvil block chuck. The steel used is shankless, one and one-eighth-inch solid cruciform section with four point cross bits. The bits are the fourteen degrees and five degrees double tapered with one-eighth inch change in gauge and eighteen inch run.

When the ore bodies are wide the stoping is done by the block system. That is, stopes six sets long and four or six sets wide, depending on the width of the vein, are carried up from one level to the level above. A chute and manway is carried up at one side of the block, usually along the footwall and on the end of the stope toward the ground which has not been mined. The manways are built with a ladderway at one side and a timber slide built of 2-in. lumber to guide the timbers being hoisted or lowered into the stope.

As these block stopes are raised the gob is kept filled with waste picked from the broken ore on the grizzly over the chute. In case this is not sufficient to keep the level of the filling close up to the working floors, waste rock is also dumped in from the level above down the chute which was formerly carried up when working the previous block.

The chute being carried up with the stope is used for delivering the ore to the level. Slides are built in the stope running down to the chute so that the ore can be transferred into the chute from a point close to where the rock is blasted, doing away with the labor and cost of mucking and wheeling the rock across the stope to the chute. The top of the chute is covered by a grizzly and all waste is picked out of the ore and thrown into the stope for filling.

When one block of ground has been mined and filled a new stope is started using the chute and manway left by the finished stope for transferring the waste for filling from the level above. This new stope carries up a new chute and manway to be used later in working the next block of ground.

The block system of square setting is recommended where wide stopes with heavy ground is encountered. Very little ground is opened at one time as one block is filled by the time

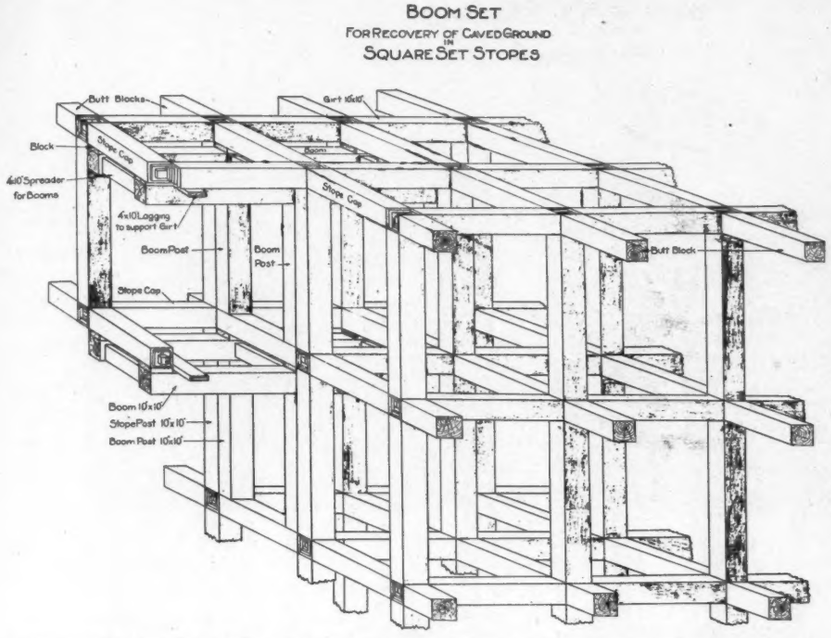


Fig. 3—The timbering in wide stopes when using boom sets for recovering caved ground.

that another is started and there is not so much chance of large caves occurring as where a large continuous body of ore is worked at one time.

The cost per ton of ore in square set stopes is somewhat higher than in open rill stopes owing to the additional labor in mucking, tramming the ore when slides are not used and the additional cost of the timber and timbering.

The Recovery of Caved Ground

The square set stopes described above are used where the ground is badly broken up by faults and cracks and must therefore be held in place by timber while mining and by waste filling as the mining advances. Sometimes a cave-in will occur. This is usually due to lack of filling and increased heaviness of the ground, which strains the timber, twisting the square sets and weakening them until a cave occurs. These caved areas are usually worked out, as the broken rock carries ore which can be saved and it is also necessary to get through the cave in order to mine the vein beyond. There are several methods used to recover the caved portion of the stope, depending on the size or width of the stope and the conditions of the walls and back of the cave.

The most simple case is that of a narrow stope about one set wide. This method is shown in Fig. 2. The cave has occurred close to a raise after the first set has been mined on a new floor. The best practice in recovering caves is to start at the highest possible point, catching up the "back" and then working downwards. This gives the mines a much safer place to work, besides preventing further caving. Fig. 2 shows the front and side sections of the method called "spiling," after being advanced for two sets into the cave. The first step in the operation is the placing of the bridging over the cap which is closest to the cave.

Bridging consists of two 6-in. blocks placed at each end on top of the cap with a 4x10-in. lagging laid parallel to the cap on top of the block. This lagging is then blocked solidly to the rock above, leaving a space six inches in height above the cap through which the spiling are driven. Spiling are made of 5x10-in. timber nine and one-half feet long, with one end sawed as shown in the drawing. This length allows the spiling to be driven in to the caved rock about six feet ahead of the cap, giving room for an advance of one set when the operation is complete. They are driven through the space above the cap at an upward angle sufficient to allow the next set to be placed, with its bridging, when the rock below the spiling has been removed.

Air driven piston type drills with a steel fitted with a flat round hammer head about four inches in diameter are used for driving the spiling. The drill is mounted on either a vertical or horizontal column. The first spiling is usually driven at one side of the bridging close to the bridging block, at an angle such that when it is in place its pointed end will be above six to eight inches beyond and above the next cap and close to the wall. The remaining spiling are driven at such angles that they "fan" out and form a complete covering for the set of timbers to be put in place.

As each spiling is driven ahead some of the broken rock is cleaned away from underneath it in order that if any large pieces of rock are encountered ahead of the spiling they can be barred out of the way or taken out. These spiling are blocked down or "tailed down" at the back end by blocks between them and the tagging of the last set or the spiling as the case may be.

When the complete set consisting of from six to eight spiling, is in place, the broken ore and rock is removed from the set beginning at the top, directly under the spiling. The side boards and breast boards are put in as the broken rock is removed. This is shown in Fig. 2, Section AA. The side boards are necessary only in order to hold the breast boards in place until the set of timber is put in place above the timber which is shown on the floor below. When this leading set is side blocked, the bridging is put in over the cap and ends of the spiling blocked up over the bridging lagging. This method is continued along the stope.

In case that the "back" of the cave slopes

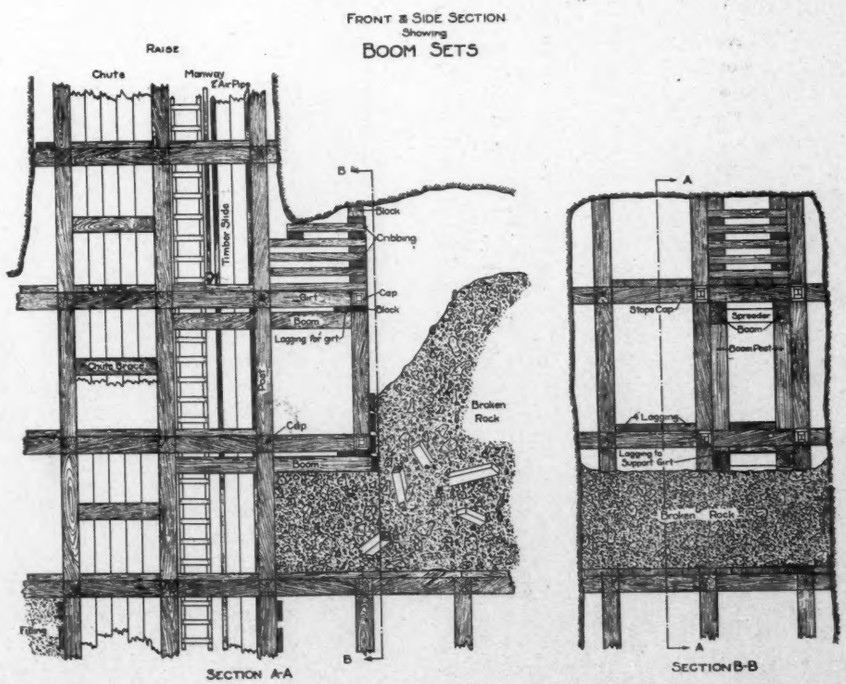


Fig. 4—Showing details of boom sets used in the recovery of caved ground in stopes where the "back" is horizontal.

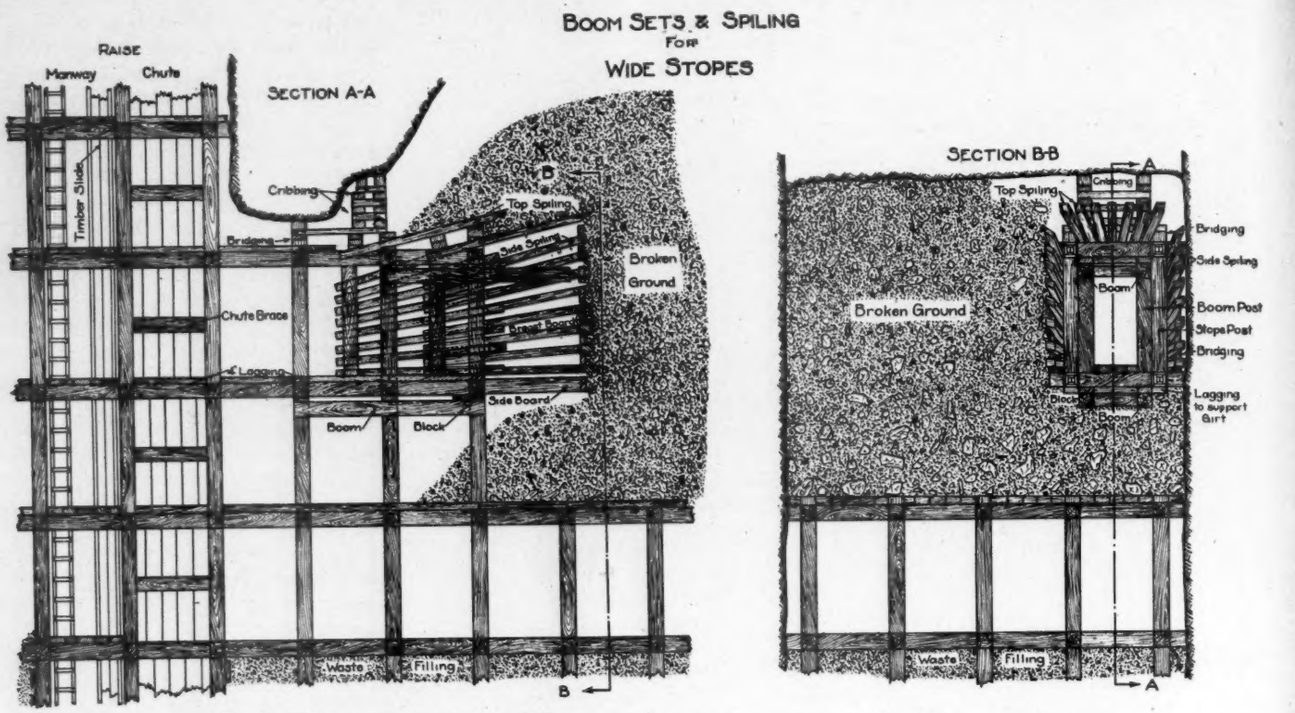


Fig. 5—The use of both spiling and boom sets in caved stopes where the back slopes steeply.

upwards from the timber two or more sets can be completed, then the brow above the timber, and close to the raise can be either barred down or blasted down taking care to blast lightly. Square sets connected to the raise timber are used to hold up the back being blocked or cribbed up above the sets depending on the condition of the rock. If the pile of caved rock rises sufficiently so that spiling must be used on the upper floor, boom sets can be used in working down under the spiling to the timber left standing below the cave. This is described later under the subject of "boom sets."

When a cave occurs in a wide stope the method of working through the caved rock is a little more complicated. As in the narrower stopes the method of attack varies with the conditions of the stope after the cave occurs. Recovery of caved ground in wide stopes is usually done by using what is known as "Boom Sets." This method is shown in Fig. 3. This drawing shows, at the left, one of the boom sets in advance of the timber left standing by the cave.

"Booms," either 10x10-in. by eleven and one-half feet long or in very heavy ground 10x12-in. by eleven and one-half feet are run out into the caved area below the first two caps in the timber back of the cave and nearest the top of the cave. One boom is used under each end of the cap, with 4x10-in. spreaders between to hold the booms solidly against the posts supporting the cap, as shown in the drawing. Each boom is supported by a boom post under the cap nearest the cave and is tailed or blocked down with a four inch block under the next cap back in the timber. A four inch block is also put between the boom and the cap of the first set of timber, in order to have the boom level. The length of the booms will allow them to support a cap for the set ahead and at the proper distance from the timber not affected by the cave. This cap is also set up on four inch blocks, in order to have it level with the other timber. Next a 4-in. lagging is laid across the two booms just behind the caps to support the two girts which are laid in place. The cap and the two girts are laced to the timbers behind and cross laced to keep them in place. This gives a support out under the solid back of the cave, which can be caught up and held steady by cribbing on top of the cap and girts that are held up by the booms.

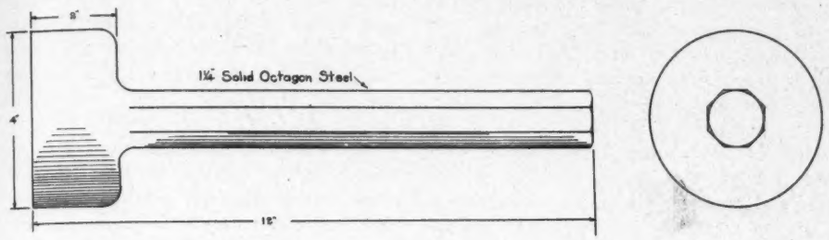
With the added safety of this steadying of the solid back of the cave, the miners can start on the floor below laying the booms on the pile of broken rock, placing the cap, girts and the posts which support the timber already in place above. This is illustrated in Fig. 4, which shows the complete first square, set ahead into the caved area, with the cribbing holding the solid back of the cave.

Square set stoping in the Butte district with CC-21 Stopehamer drills.

The rock below the set can be removed and another pair of posts can be put in place making the timbers complete down to the old timber, left below the cave. The same procedure can be followed, starting at the top, as described, and working the next set to the side of the first one advanced down to the old timber. In this way the timber can be advanced a set ahead across the stope and then, starting ahead at one side of the stope, the whole operation is repeated until the cave has been completely timbered and the broken ore and waste has all been removed.

Another condition of caved ground is illustrated in Fig. 5. In this stope the solid back of the vein, after the cave, was left at a steep angle sloping up from the timbers left standing. Owing to the broken rock being so high above the timber it was impossible to start a boom set, as in the former case. It was necessary to start making room ahead of the highest sets, by using the spiling method described above. Instead of using only the top spiling, both top and side spiling were necessary for making room for a set of timber. The top spiling is usually driven home first, then as the top side spiling are driven, and the rock is removed, breast boards are used to hold the broken rock from running into the open space. The side spiling is driven at an angle on the outside of each of the posts to give plenty of room for timbering when the rock is cleaned out from in front of the standing timber.

After the top booms are blocked and the



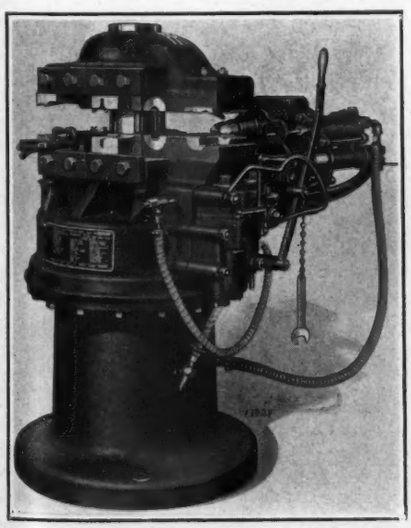
HAMMER BIT
used for
DRIVING SPILING

Type of hammer bit used with Ingersoll-Sergeant piston type drills for driving spiling.

caps and girts of the top of the set are in place, the top spiling can be blocked or cribbed up in order to brace them and prevent their breaking.

The broken rock in the set below can be partly taken out and booms used to support the cap, girts and posts on the floor below, as in the case of boom sets described above. Fig. 5 shows the advance of two sets in the line of sets, next to one of the walls of the vein. In section BB the breast boards are not shown in order that the rest of the timber may be seen more clearly. After the first line of sets along the wall is complete for two sets the work is started in the next line of timber and is advanced two sets into the cave. This operation is carried across the stope until the other side of the stope has been reached. While the upper two sets are being carried across the stope a second crew of men can be employed clearing the broken rock on the lower floor above the standing timber and putting in the posts which would connect the boom sets to the timber below. When this advance of two sets is finished the timbers are well blocked from both walls of the stope.

The next step in this case would be to start on the next floor of the raise. The brow of rock next to the raise is removed by barring or by blasting lightly. The first two sets from the raise are timbered taking special pains to block or crib up to the back to hold it steady.



Leyner No. 50 sharpener with shank and bit punch attached. Rapidity of drilling speed has been greatly increased by the use of this sharpener.

From these timbers it would be possible to work out over the timbers below and two sets in advance of them using the spiling to make room for timber and using the boom sets as before, for the two sets advanced into the cave. These two sets can then be worked on down to the lower timbers standing below.

In this way, working from the top downward, the cave can be cleaned up without the danger of the miners working under a back so high over their heads, that barring down of the loose rocks would be impossible. The pile of broken rock ahead of the timbers suffices to hold the walls apart and in case the back of the cave "sluffs" off or breaks off, the broken rock will soon fill the space up to the back and prevent further caving, until the timbering has caught the back and definitely prevented caving.

There are several things to watch closely in using spiling. If the caved rock is muddy and wet, it is best to block all of the holes between the spiling with pieces of wood to prevent leakage of mud and water.

Sometimes it is necessary to fill all spaces with rags, waste or anything that is handy to prevent the fine sand and mud from running through the spaces between the spiling.

When driving the top spiling care must be taken to drive them at such an angle that they will clear the set to be put in ahead, with its bridging in place, ten inches above the cap, and the side spiling should be driven to give plenty of room on each side for placing the posts. It is also necessary, when using spiling and boom sets together, that the back end of the driven spiling be high enough so that they will not interfere with placing the booms for the set ahead.

These few examples of the way in which caved ground is recovered will give an idea of the many and varied methods used for this work.

A technical paper entitled "Gas Masks for Gases Met in Fighting Fires" has been issued by the Bureau of Mines. It is a very complete treatise on gas masks, giving descriptions of various types of masks and breathing apparatus and telling their applications and also limitations. It is brought out that the army gas mask while capable of giving complete protection against the deadly gases met on the battlefield, does not protect against all the gases or atmospheres encountered in mines, in the industries and in fire fighting.

ANIMALS AS MINING TERMS

THE METAPHORICAL uses of the names of animals as discussed in a recent issue of the Hercules *Mixer*, is an interesting study. We are all familiar with the common application of the names of such species as the stag, the fox, the chicken and many others which are used in daily conversation. However, there are probably very few readers who are familiar with the various names of animals that are used as mining terms. The following examples will, therefore, be of interest because of their unusual application.

The term "bulldog" in mining means a small car that is used on inclined planes or slopes.

"Cows" are found in many mines. Unfortunately they do not produce milk, but in reality are self-acting brakes.

A "bug" hole is a cavity in a vein or country rock usually lined with crystals.

Bad breaker boys at coal mines may sometimes be called brats, but the word "brat" denotes to a coal miner a thin bed of coal mixed with pyrites or limestone.

Mining "dogs" do not bark because they are only iron bars spiked at the ends used to hold timbers together. Another use of the word "dog" in mining is for a short heavy iron bar used as a drag behind a car or trip of cars when ascending a slope, to prevent the cars from running back down the slope in case of accident.

Real mules are common in coal mines, but a "horse" to a coal miner means a portion of a coal seam that has been filled with shale or other rock, on account of being a water channel at one time.

"Crabs" occur in even the dryest mines—they are a variety of windlass that has a short shaft or axle used as a rope drum for raising weights.

As far as we know no mice have ever been caught by a mining "kitty," because this variety of the feline family is a squib made of a straw and filled with powder.

A "monkey" gangway instead of being a promenade for apes, as the uninitiated might imagine, is a small gangway parallel with the main gangway or entry in a coal mine.

Pigs may be pigs in ordinary life, but at mining operations a "sow" is a tool used for sharpening drill steel.

Even the products of mines are some times described as animals, for example—"parrot coal" is a kind of coal that splits or cracks with a chattering noise when on fire.

We can readily imagine that if a mining man used any of the above terms in a conversation with one who was not familiar with their use, there would be somebody minus his "goat."

"The Bulletin," the monthly publication of the general Contractors Association has announced a return to its old field of the Association after having spent two years as the organ of the Associated General Contractors of America. The A. G. C. will carry on with its own publication, *The Constructor,* devoted to the national aspect of construction and the Bulletin will resume at its old stand, dealing with its own problems.

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EDITORIALS

SELLING OUR INDUSTRIAL MACHINERY ABROAD

AMERICA'S POSITION in the machinery market abroad is in a fair way to be materially bettered, thanks to the increased activities of the United States Department of Commerce. There has been created within the Bureau of Foreign and Domestic Commerce what is now known as the Industrial Machinery Division, and the purpose of this organization is to defend and to promote the interests of our manufacturers of machinery coming under the classification specified.

We have latterly grown accustomed to hearing that our business in the markets of the world has slumped woefully, and it is certainly a gratifying surprise to learn that this is not the case with some branches of our productive life—conspicuously so in the realm of industrial machinery. During the calendar year of 1913, we shipped out of the country industrial machinery to the value of $92,312,457, and for eleven months of the past year our exports of this sort were worth $238,007,585. It has been authoritatively estimated that the total of these shipments for 1921 will reach, when all of the reports are in, an aggregate of more than $250,000,000—in other words, represent a ratio greater than 270 per cent. of the business in this line in 1913.

The matters coming under the cognizance of the new division embrace the following: Air compressors, concrete mixers, elevators and elevator machinery, engines, excavating machinery, flour and grist-mill machinery, power-laundry machinery, machine tools, metal-working machinery other than machine tools, meters for gas and water, printing presses, pumps and pumping machinery, railway cars, type-setting machines, and machinery for paper and pulp mills, refrigeration, road making, shoe manufacturing, sugar mills, textile mills, and saw mills, etc.

The production of the foregoing commodities calls for the operation of more than 4,000 factories. These plants carry on their payrolls something in excess of 400,000 employes; and the wages earned by these people bear directly upon the welfare of fully 1,500,000 of our citizens. The value of the output of the shops is over $2,200,000,000. Three years ago, we exported wares equal to nearly 17 per cent. of this total, indicating a foreign trade amounting to about $1,000 per employe. The Chief of the Industrial Machinery Division, W. H. RASTALL, has recently stated: "This figure ought to be doubled, and, with the application of American salesmanship and good business methods, this should be accomplished."

To this end, men who are qualified engineers and who have sold a great variety of machinery in South America and Asia for a number of years, and are personally familiar with conditions existing in many of the cities of those countries, have been placed in charge. The Industrial Machinery Division aims to be of the greatest possible assistance to American manufacturers and exporters of machinery. Should circumstances warrant, arrangements will be made to send special investigators into those regions; and such tasks would be assigned only to experts peculiarly qualified for the work. This service will be rendered whether the ultimate gain be large or small.

In the several markets of the world different sales methods are employed in selling machinery, and the specialists of the Division are familiar with them. Where experience shows that it is best to trade through agents or dealers, reasonably complete lists of all available candidates in each of the important cities abroad are obtainable.

The Government's oversea representatives supply the Division constantly with information concerning new engineering enterprises; and the aim of the organization is to notify American manufacturers of the locations where business is thus developing.

The Industrial Machinery Division has latterly begun to assemble the laws and regulations of all foreign countries covering the inspection, construction, and operation of steam boilers, air receivers, and similar containers. In coöperation with the Electrical Division it plans to secure a similar collection of the electrical regulations of the world. A general survey of the railway mileage and rolling stock of the world is in preparation.

Heretofore, because of the excellence of American machinery and of the engineering skill they represented, Europe has absorbed immense quantities of our labor-saving apparatus, and now other channels of trade are opening up to maintain and to increase this business. Asia is undergoing a portentious transformation, and there is ample warrant for the belief that Japan, India, and the Dutch East Indies will develop very rapidly.

The makers of industrial machinery should rejoice in the creation of the Division and work with it wherever practicable to the end that our export trade in apparatus of this nature may reach annually the prophesied value of eight hundred million dollars.

"LEST WE FORGET"

IT SHOULD, indeed, be a source of satisfaction to Americans that their Government took the initiative in calling the nations together in the recent conference at a time when maritime powers were generally bent upon increasing rather than decreasing the proportions of their fighting fleets; and agreeably to the measure of this trend the peoples concerned were in a fair way to be burdened with additional taxes. Happily, this tide of defensive extravagance has been halted at the flood. The term "flood" is used advisedly, because an analysis of the lists of battlecraft allowed under the treaty to the various signatory nations will reveal that the respective navies from now on for the next ten years will be, judged by matériel alone, a good deal more formidable than heretofore.

With the completion of the ships building or nearing readiness for commissioning, the first line of defense of the subscribing powers will actually represent the very climax of sea might. In other words, to bring the situation home to us, the vessels that will be at our disposal to safeguard our rights and dignity will put us in an armed position afloat which has never been ours in the past. That is to say, naval architecture, ordnance engineering, and the mechanical arts in many directions have all contributed to produce types of craft of the most advanced sorts and capable of splendid service in the hands of an equally efficient personnel.

The popular conception of the accepted plan for the limitation of armaments is that from now on the first line of our defense will be a far more economical organization to maintain. The man in the street points out that under the treaty we have agreed to scrap an array of ships either still on the blocks or only partly finished, and that we are going to relegate to the junk heap an imposing number of older battleships that are at present tied up and more or less of a useless drain upon the public purse. And the uninformed citizen mistakenly jumps to the conclusion that the active fleet which is to remain will cost us comparatively little for upkeep because he assumes that its less numerous components will involve a reduced annual expenditure. This is not going to be the case unless we make a grave error and allow ourselves to cripple the force which we are entitled to by the terms of the conference.

However much we may desire to welcome the advent of universal peace, we must recognize that the world is still in a state of flux.

Anent this phase of the limitation of armaments, it may be pertinent to point out to the public that abroad the subscribing members to the recent treaty are intent upon increasing the personnel of their fleets while adhering to the agreed reductions in matériel. The Vice-Minister of Marine of Japan made this statement recently, according to a correspondent of the *New York Evening Post*: "The Japanese people may rest assured that no effort will be spared to determine how the funds thus saved for the nation (by the limitation of naval armaments) may be best applied, and that every care will be taken to preserve and develop the efficiency of the navy in its supreme task of insuring the safety and well-being of the empire."

On the other hand, the British Navy on July 1st, 1921, had an enlisted strength of 104,000. While exact information is not available regarding the Japanese Navy, it is known that the enlisted men of the fleet and the corresponding personnel of the naval reserve aggregated 106,000, and that the commissioned personnel totalled 3,600 as against 4,100 in the regular Navy of the United States. On the 1st of January of the current year, we had only about 600 officers, out of the total line strength of the Navy, who, by reason of length of service, could be considered ripe in experience. The ratios of officers to men in the British and the Japanese navies are higher than the ratio existing in our sea branch of the national defense.

Surely, both Congress and the public generally should ponder these facts before sanctioning any unwise steps involving a too great reduction of the fighting fleet's personnel.

CABLE COMMUNICATION WITH PETROGRAD COMPLETED

ONE OF the principal lines of cable communication between the United States and Petrograd, Russia, before the war was by way of Great Britain and thence over the North Sea cable controlled by the Great Northern Telegraph Company, a Danish concern with headquarters in Copenhagen. This route reached Petrograd by way of Helsingfors. During the war the line was kept open—but after the overthrow of the Kerensky government the property belonging to the Danes was seized by the "Soviets" for the benefit of the "People." However, the "People" did not benefit greatly thereby, because the line was destroyed almost immediately owing to the outbreak of hostilities between the more conservative Finns and the Bolsheviki.

For a long time there was no direct communication of any sort between Russia and Western Europe, because all service via Poland and the Baltic States was interrupted through almost continuous strife. Then communication was gradually built up with Moscow through the Baltic States—but service was subject to the most preposterous delays, and there were varying degrees of censorship to be passed through en route. Private messages were not accepted for transmission beyond the Baltic States.

Some few months ago the "Soviets" came to an understanding with the Danish Company, and the Great Northern sent a number of experts to Petrograd to rehabilitate their old terminal. We are informed that the work on the Petrograd Station is now practically complete so that direct communication will shortly be possible. As formerly, the line will go via Helsingfors.

After several years interruption it will accordingly be possible to have quick communication with the old Russian capitol, although we do not predict what the "Soviet" census may do to the messages that you might send of which they do not approve.

BELGIAN GOVERNMENT SUPPORT FOR AVIATION

ABOUT A YEAR ago the Belgian Minister of War decided to create an aerotechnical laboratory for the purpose of encouraging aviation in Belgium and providing facilities to enable Belgium constructors to keep abreast with scientific development along that line. The site selected for this new establishment was in the vicinity of Rhode-Saint-Genese and considerable progress has already been made with construction and the heavy work is rapidly approaching completion.

This laboratory according to a description given in the *Chronique Des Travaux Publics* when completed will cover an area of approximately three hectares. A large hall occupies the central location; this structure is about 185 ft. long and it houses a Venturi tube of enormous dimensions which is provided for the purpose of conducting experiments with models. The wind through the tube is created by a large fan driven by a 500 h.p. motor and with this equipment it is possible to induce an air current within the tube approximately reaching a speed of 300 kilometers an hour or approximately 187 miles per hour.

Aside from this wind tunnel the laboratory will contain a work shop and testing department for analyzing various materials and testing their strength, drafting rooms, offices and conference rooms. The total cost will exceed 800,000 frs. when completed.

One of the problems that has been given careful consideration is to provide adequate heating for the compartment occupied by the experimenters within the tunnel, because in a location exposed to such violent air currents difficulties are present that require very careful thought to solve. The 500 h.p. motor used for driving the fan is being constructed at the works of a well known manufacturer in Charleroi. This motor is a distinct novelty in electrical construction.

The Belgian Government has made every effort to produce a plant of the most modern type which will embody the latest branches of science in the field of aviation and they are justly proud in having produced an experimental station which they do not believe is excelled in any other country in the world. Special emphasis is laid upon the fact that this is not a purely military establishment. To be sure study will be devoted to the questions affecting military aviation, but the primary object is to foster the industry as a whole and to make it possible for Belgium to become independent of outside sources of supply not only for air planes but for the other scientific equipment used by aviators or required by experimenters and designers. This is an excellent example of what should be done to perfect the science and art of commercial aviation at least, regardless of what may be done along military lines. Institutions of this kind will no doubt tend to discourage ill considered attempts to fly either by dirigible or airplane without sufficient experimentation to warrant such efforts.

THE EMERSONIAN MOUSE TRAP THEORY

WE THINK it was EMERSON who once said that if a man were to build a perfect machine of any kind—the most perfect machine ever made—even if it were nothing but a mouse trap, and were to retire to the depths of the forest, the world would find him out and beat a path to his retreat to buy the product of his genius.

Westinghouse built the most perfect air-brake ever constructed and it hasn't been much improved upon since. According to the Emersonian theory he should have retired to the woods so an appreciative world might flock to his door. Had he done this, our trainmen would probably be still laboriously twirling the old brake wheel.

But Westinghouse, fortunately for him and us, had never heard of this theory and, instead of going into a wooded retirement, he hustled out on the job and convinced the world by argument, personality and demonstration, that he had the most perfect machine ever made for controlling railway trains, and a difficult time he had in doing it at that.

Conceive of a colony of Eli Whitneys, Stephensons, Morses, Bells, and Edisons, not to mention Henry Fords. A nice pleasant aggregation they would make (pardon the anachronism) waiting in their forest shade, each with his perfect cotton gin, locomotive, telegraph, telephone, phonograph and flivver, waiting for the world to flock to their feet! Visualize the state of industrial advancement had these geniuses stayed in the forest as Emerson would have them!

It has been said of Emerson that he was one of the clearest thinkers of his day but when he promulgated the mouse trap theory, as it has been called, he displayed a lack of knowledge of scriptural teachings which tell us not to hide our light under a bushel, and of also one of the fundamentals of business which, even in his time, was a recognized fact, namely, that, in order to be successful, one must blow his own horn.

Think again of what we would miss under the Emersonian theory which would deprive us of the delights of Tootsie Rolls, Old Dutch Cleanser, Uneeda Biscuits, Boston Garters, Camel Cigarettes, and a host of other "necessities" while their inventors were waiting for the world to find them out.

No, MR. EMERSON, the world long ago rejected the mouse trap theory for it knows better. It knows that "It pays to advertise."

A new natural gas field has been discovered in Northern Louisiana which is estimated by the Bureau of Mines to hold about five *trillion* cubic feet, making it the greatest natural gas supply yet discovered.

In a general study of drill steel problems, being conducted at the Mississippi Valley Station, a report on the results of rock drill tests in the Missouri-Kansas-Oklahoma zinc district has been completed. Another phase of the drill steel problem, to determine the best composition of a straight carbon steel for drilling in granite, has been assigned to two "fellows" in the Missouri School of Mines, with Prof. C. R. Forbes and C. Y. Clayton acting in an advisory capacity. Plans and specifications are being drawn for constructing an oil fired furnace to heat drill steels.

The United States now has 53 per cent. more tanker tonnage than the United Kingdom. American-flag tankers have accounted for 76 per cent. of the total world increase of such tonnage since 1914. Only 55 steam tankers, totaling 201,000 gross tons, were flying the American flag in 1914; seven years later there were 356 oil carriers under American registry, with a tonnage ten times that in 1914, according to a table compiled by the Bureau of Navigation.

The rapid development of our fleet of tank ships is the story of our increasing dependence upon Mexico for crude oil; in 1914 the United States imported 3,100,000 barrels of oil; in 1920, 105,600,000 barrels.

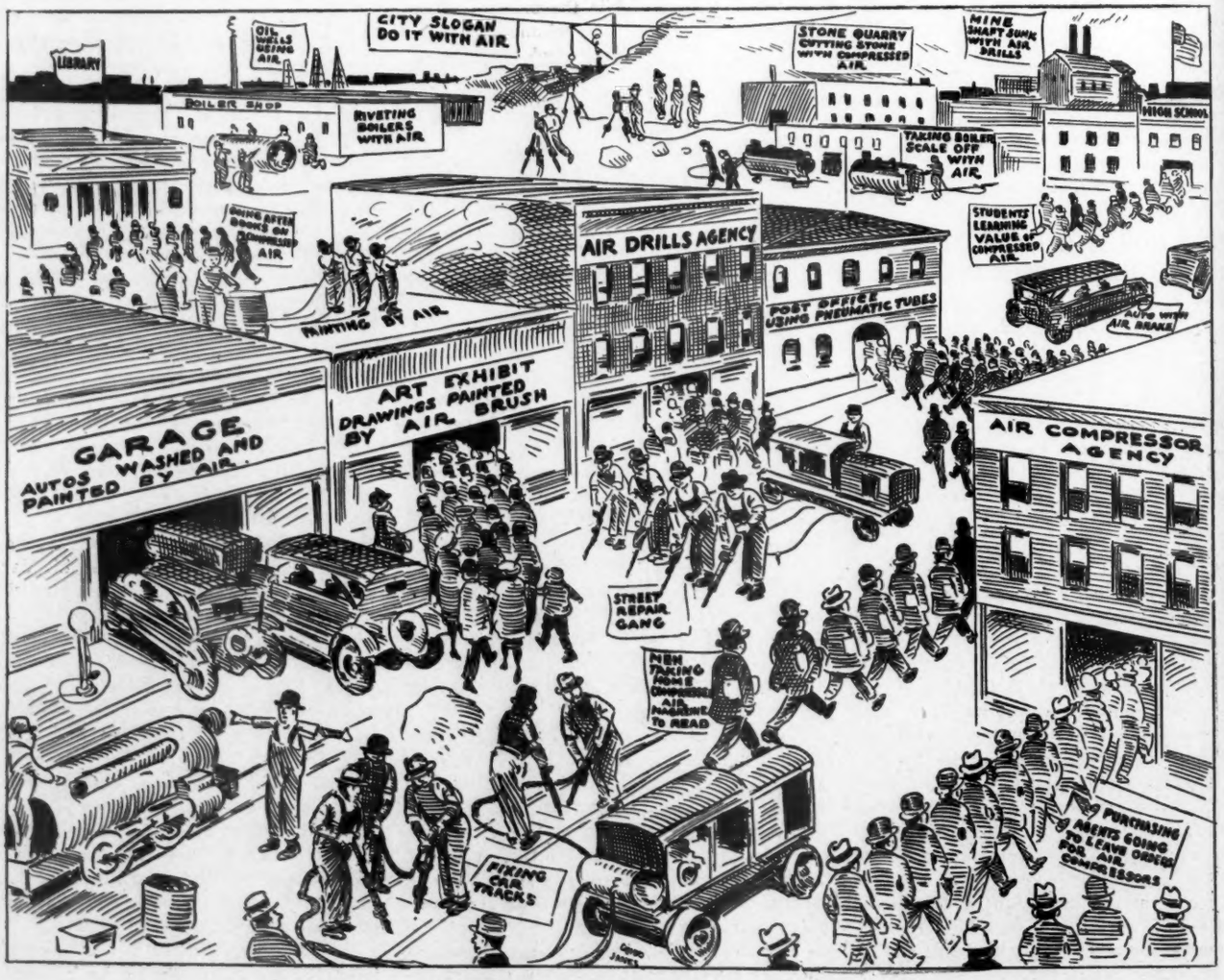
Records of the American Association of Engineers show that unemployment among professional technical men is small as compared to the trades. Roughly estimated about two per cent of the technical men are actually unemployed.

A mechanical messenger, with the speed of Winged Mercury, is to be a feature of the communication system at the new Bank of Italy, head office building, San Francisco.

The system installed by the Lamson Company is the largest in any bank on the Pacific Coast, and is known as the "Bell Mouth Power Control" type with 27 stations or independent lines reaching 27 points in the building. The Central Station will be on the Mezzanine, with connections terminating in each department at the bank. More than a mile of tubing has been used in completing this installation, which involves some 500 curves or turns. Each station is equipped with five carriers, capable of moving at the rate of 50 feet per second. Messages from any point in the bank can reach the central desk within five seconds. Power is provided by a turbo compressor, with a capacity of 2,000 cubic feet of air per minute.

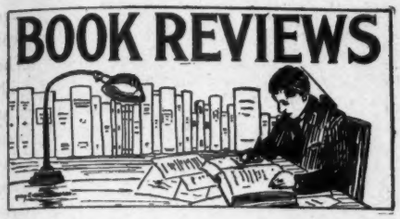
Co-operative arrangements have been made with the Air Service, effective at certain flying fields, for furnishing planes when requested by the Bureau of Mines, for carrying the district safety engineer or his assistants with rescue apparatus to mine disasters in the district.

The damaged coal mines in Northern France are being repaired faster than was anticipated at the close of the war. They are expected to be in normal working order by 1926 instead of 1930 as was originally estimated.


CITY SLOGAN DO IT WITH AIR
LIBRARY
OIL WELLS BEING AIR
BOILER SHOP
RIVETING BOILERS WITH AIR
STONE QUARRY CUTTING STONE WITH COMPRESSED AIR
MINE SHAFT SUNK WITH AIR DRILLS
HIGH SCHOOL
TAKING BOILER SCALE OFF WITH AIR
USING AIR DRILLS ON COMPRESSED AIR
AIR DRILLS AGENCY
STUDENTS LEARNING VALUE OF COMPRESSED AIR
POST OFFICE USING PNEUMATIC TUBES
AUTO WITH AIR BRAKE
PAINTING BY AIR
ART EXHIBIT DRAWINGS PAINTED BY AIR BRUSH
GARAGE AUTOS WASHED AND PAINTED BY AIR
AIR COMPRESSOR AGENCY
STREET REPAIR GANG
MEN TAKING HOME COMPRESSED AIR MACHINE TO READ
PIKING CAR TRACKS
PURCHASING AGENTS GOING TO LEAVE ORDERS FOR AIR COMPRESSORS

THE AGE OF COMPRESSED AIR

BOOK REVIEWS



INDUSTRIAL HYDROGEN, by HUGH S. TAYLOR, D. Sc., Asso. Professor of Physical Chemistry, Princeton University. A new volume in the American Chemical Society Monograph Series. 200 pages with figures and tables. New York: The Chemical Catalog Company, Inc.

FUNDAMENTAL principles and essential chemical facts of the industry of hydrogen production are outlined in this monograph. A readable account of available knowledge of this subject is presented. It traces the steps by which the present status of the industry has been reached and details what that present status is and what lines of future development may be anticipated.

The production of hydrogen on a large scale is an industrial development of the last two decades. Prior to 1900 the uses of hydrogen was practically confined to the aeronautical field, for use in balloons, and to a few minor industrial uses and the production of "lime light."

From 1900 onwards the demand for large scale hydrogen production has steadily increased. The dirigible balloon made this production imperative. The dirigible ZR-2, recently destroyed, had a capacity of 2,700,000 cu. ft. of hydrogen. But, at the same time, considerable development occurred in the purely industrial use of the gas. In catalytic hydrogenation processes in the chemical industry, it is estimated, several million cubic feet are daily consumed in this country alone. The use of the oxy-hydrogen flame is well known to all.

Air or gas compressors, in their various types, have been a necessary part of the equipment in many of the methods of hydrogen production, particularly in the water-gas and steam, and water-gas processes. In these, many of the high pressure units are in use, in the main, of three-stage and five-stage varieties.

BURNING LIQUID FUEL, by DR. WILLIAM NEWTON BEST, Fellow of the Royal Society of Arts, London, Member Am. Ry. M. Mech. Asso.; Am. Soc. M. E.; Am. Inst. Min. and Met. Eng., Inter. Ry. Fuel Asso., etc. 337 pages, 6x9 in. Over 300 figures and illustrations. Price $5.00 net. New York: U. P. C. Book Company, Inc.

IN THE COMPILATION of this edition of the Science of Burning Liquid Fuel the author has given data which covers all the various forms of equipment. This has been obtained from thousands of actual tests, and is the result of knowledge gleaned from more than 33 years' experience in the burning of oil and tar. The result is a practical treatise on the perfect combustion of oils and tars giving analyses, calorific values and heating temperatures of various gravities with information on the design and proper installation of equipment for all classes of service.

The language used will be readily understood by men in all fields, by the shopman as well as the technical student or engineer. The equipment shown has been selected from thousands of installations in successful operation and reveals the most modern applications of liquid fuel so as to obtain perfect combustion. The various industries are covered in separate chapters so that the best practice for any particular problem can readily be ascertained.

In an introductory chapter on atomization, compressed air is closely linked with perfect fuel combustion. The author states: "It is therefore essential that liquid fuel be thoroughly atomized so that the oxygen of the air can freely unite with it. Except where mechanical burners are used the fuel is atomized by means of high or low pressure air or steam. Compressed air or steam is preferable to low pressure air because it requires power to thoroughly atomize liquid fuel. With low pressure or volume air you are limited to the use of light oils whereas with compressed air or steam as atomizer you can use any gravity of crude oil, fuel oil, kerosene or tar which will flow through a one-half inch pipe. . . . In furnaces the most economical method of operation is the use of a small quantity of compressed air or dry steam through the burner to atomize the fuel while the balance of the air necessary is through a volume air nozzle. Every particle of moisture which enters a furnace must be counteracted by the fuel. . . . Numerous tests have proven that with steam at 80 lbs. pressure and air at 80 lbs. pressure there is a total net saving of four per cent. in favor of compressed air."

MASONRY STRUCTURES, by Frederick P. Spaulding, Professor of Civil Engineering, University of Missouri. 404 pp., 129 figures. 6x9. Cloth. $3.50 postpaid. New York: John Wiley & Sons. London: Chapman & Hall.

THIS BOOK is designed to present, in a brief and systematic manner, the fundamental principles involved in the design and construction of masonry structures. The term Masonry has been construed to include concrete, so that the field covered by the title is a very wide one.

Among the branches of the subject treated are Cementing Materials, Stone and Brick Masonry and Plain Concrete. The properties of these important building materials are thoroughly discussed as is also their use. A chapter on the Ordinary Theory of Reinforced Concrete giving formulas and tables for use in the design or investigation of reinforced beams, columns and slabs is of great use to those engaged in this work. Retaining Walls, Dams, Reinforced Concrete Slab and Beam Bridges are also dealt with in a practical manner.

A new bulletin on the Quigley Fuel Systems, comprising methods of preparing, transporting, and burning of pulverized fuels has just been published by the Hardinge Company, 120 Broadway, New York.

Aside from complete plant layouts, what they term as a "Unit Milling Plant" is described. This layout is said to be radically different from anything ever before developed. The system comprises a method of pulverizing and transporting the coal to one or more furnaces in the same locality, at the same time securing positive regulation and continuous operation over extended periods.

A feature of the system, outside of the mill, is the method of transporting pulverized fuel. In transporting a finely divided fuel the use of compressed air has been found most satisfactory and a method of applying this power has been developed which is economical and simple to operate. The Quigley Air Transport system has practically no moving parts and is very easily controlled.

From the partial list of users shown in the back of the book, it is evident that the facts as presented in this catalog are backed by a considerable amount of experience, for not only does this list include companies in many classes of industries, but the range of capacity for the complete pulverized fuel plants is extreme, the largest being that of Ougree-Marihaye, Belgium, with a capacity of 600 tons of pulverized fuel per day, which we understand is being used for burning under boilers, forge furnaces, heating furnaces, reverberatory furnaces, and continuous furnaces.

Personal Intelligence

Mr. Geo. W. Jackson, engineer, died in the Evanston hospital, Chicago, after a short illness of pneumonia. Mr. Jackson was contractor for the Stickler Tunnel through Pike's Peak; for the pneumatic tube system of the Associated press, and about 90% of the entire underground system for the Chicago Telephone Company, and The Western Union and Postal companies of Chicago.

* * *

Hon. Geo. R. Smith, member of the Legislative Council, and general manager of the Bell's Asbestos Company, Thetford Mines, died at his home recently, after an extended illness. Mr. Smith has for many years been a leader in asbestos mining development, energetic and enterprising, and his demise will be regretted by many, including the Canadian Mining Institute, and Montreal and Quebec Boards of Trade, of which organizations he was a member.

* * *

Mr. Henry P. Corbin, consulting engineer of the International Boundary Commission between United States and Mexico, died at El Paso, Texas, recently. Mr. Corbin was appointed to the post of consulting engineer October 7, 1914.

* * *

Mr. Geo. F. Wolfe has resigned as chief designing engineer for the International Steel & Iron Co., Evansville, Ind., to open an office at St. Petersburg, Fla., as consulting engineer on structural steel and reinforced concrete structures.

* * *

Frank S. Dinsmore, of the staff of *Railway Age* died at the Long Island College Hospital recently. He was 62 years old.

DECEMBER 13.

1,399,805. VACCUM CAN-SEALING MACHINE. Laurence Oliver Schopp, St. Louis, Mo.

1,400,289. METHOD AND APPARATUS FOR DUSTING ARTICLES. Dwight E. Humphrey, Akron, Ohio.

1,400 313. APPARATUS FOR DETERMINING THE AMOUNT OF HEAT IN THE AIR. Carl Heinrich Prott, Rheydt, Germany.

In apparatus for determining the amount of heat in the air, a wet-bulb thermometer having a scale graduated in heat units in a given amount of air and including those in the moisture in such air.

1,400,448. VACUUM-CLEANER. Edwin E. Mellenthin, Waukesha, Wis.

DECEMBER 20.

1,400,573. SUCTION LIFTING IMPLEMENT. William Stades, Philadelphia, Pa.

1,400,639. ELECTROPNEUMATIC BRAKE. Thomas H. Thomas, Edgewood, Pa.

1,400,669-70. SAFETY CAR-CONTROL DEVICE. Samuel W. Dudley, Edgewood, Pa.

1,400,755. COMPRESSOR. Charles L. McCuen, Chicago, Ill.

1,400,801. PNEUMATIC AND HYDRAULIC CLAMP. Benjamin P. Cohen, Augusta, Ga.

1,401,003. MOTOR. William A. Smith, Phillipsburg, N. J.

1,401,100-01. SYSTEM FOR REMOVING AIR AND GASES FROM WATER. Raymond N. Ehrhart, Pittsburg, Pa.

DECEMBER 27.

1,401,325. ADJUSTABLE BRAKE ARRANGEMENT OPERATED BY COMPRESSED FLUID, ADAPTED TO BE USED IN RAILWAY-TRAINS OR THE LIKE. Gustav Droishammer, Hamar, Norway.

1,401,397. TOOL FOR APPLYING COATING. Herbert W. Day, Wollaston, Mass.

1,401,473. PNEUMATIC CONTROL FOR LUBRICATORS. Charles F. Hoofer, Chicago, Ill.

1,401,551. FLUID-ACTUATED CLUTCH-PULLEY. Frederick W. Parsons, Elmira, N. Y.

1,401,681. DEEP-WELL PUMP. Robert M. Downie, Beaver Falls, Pa.

1,401,789. DUST-CLEANING SUCTION-PUMP. Otis M. Kennedy, Philadelphia, Pa.

1,401,858. PNEUMATIC COLUMN. Lewis C. Bayles, Easton, Pa.

JANUARY 3

1,402,016. REGULATOR FOR COMPRESSORS. Ward Raymond, Easton, Pa.

1,402,267. ELECTROPNEUMATIC BRAKE. William Hatton Stevens, Philadelphia, Pa.

1,402,270. AIR-DISTANCE INDICATOR. Morris M. Titterington, Brooklyn, N. Y.

1,402,333. RELEASING DEVICE FOR AIR BRAKES. William Wallace Wood, La Fayette, Ind.

1,402,601. AIR FILTER FOR HOT-AIR FURNACES. Daniel Handelan, Aberdeen, S D.

1,402,727. POWER-ACTUATED PNEUMATIC TOOL. Bert Seaboldt and Herbert C. Brown, New York, N. Y.

JANUARY 10

1,402,939. AUTOMATIC OIL CUP FOR AIR PUMPS. Adam Lautz, East St. Louis, Ill.

1,402,978. AIR-LINE COUPLING. Frank M. Thomas, Piggott, Ark.

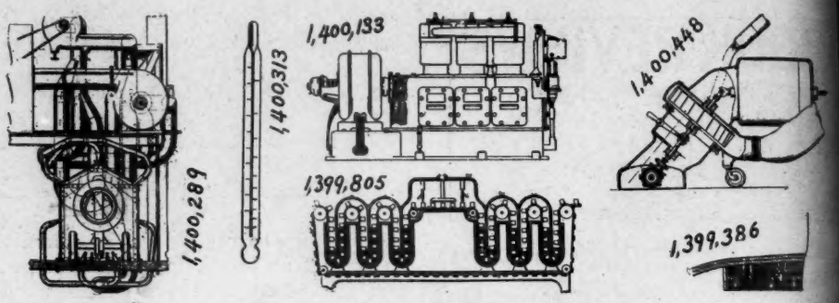
1,403,126. METHOD OF AND APPARATUS FOR TRANSPORTING AND IMPREGNATING MATERIAL. John James Lyth, Valleyfield, Quebec, Canada.

1. A method of transporting cloth in rope form, which consists in forcing it through a tube by means of fluid under pressure.

1,403,140. SPRAY PUMP. Owen D. Wiggins, Laurel, Ind.

1,403,290. VACUUM BRAKE. Roy Webber Catching, Roseburg, Oreg.

1,403,466. AIR SPRING. Frank S. Church, Cincinnati, Ohio.



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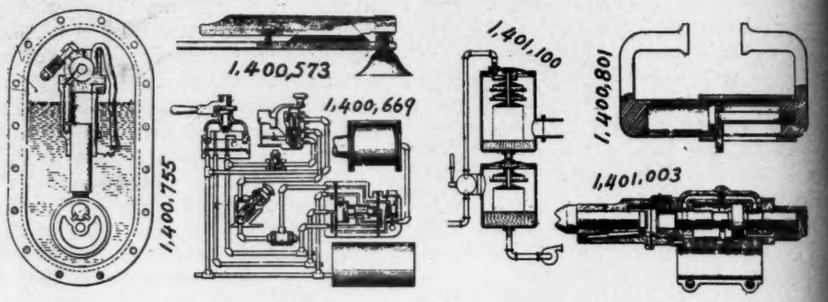

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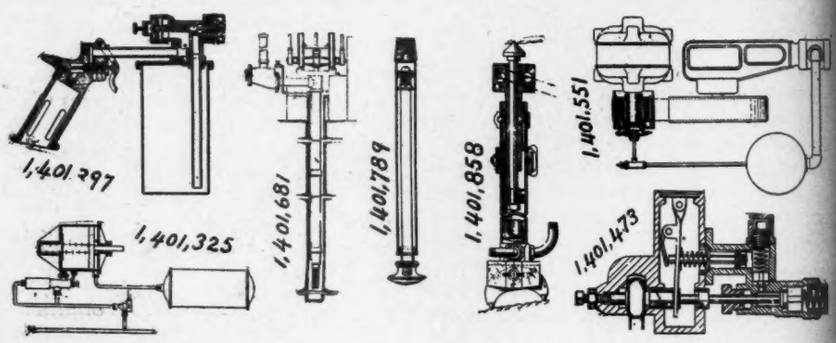

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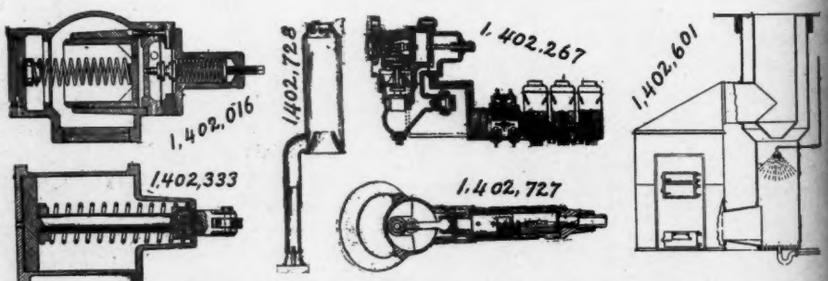
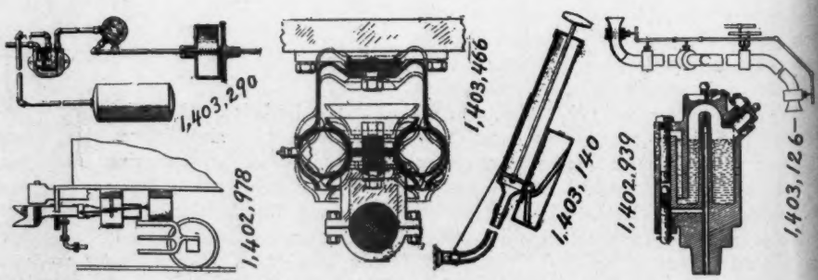


JANUARY 3



JANUARY 10

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